AVO INTERNATIONAL

INSTRUCTION MANUAL

For

PULSAR®
Universal Test System

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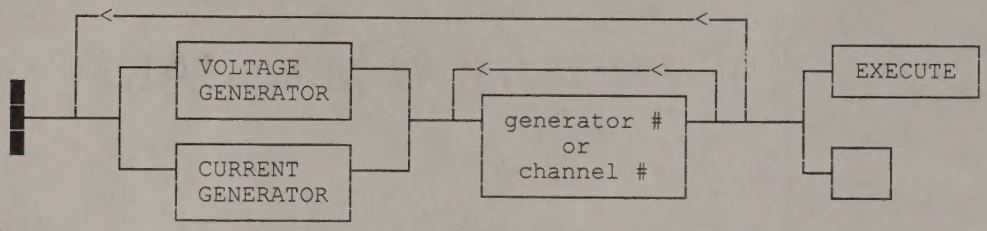
It is essential that this instruction book be read thoroughly before putting the equipment in service.

Part _ 14850
Rev. 8 Date 6/24/96

CONTROL SECTION

The right half of the module is called the **Control** section. It can be divided into five individual menus which offer the following features:

SELECT/GENERATOR:



where,

VOLTAGE - denotes the **VOLTAGE** key and indicates that a voltage generator is being selected.

CURRENT - denotes the **CURRENT** key and indicates that a current generator is being selected.

generator # or channel # - a single digit in the range of 0 to 9 indicating the generator to be included in this selection.

0 (zero) is pre-defined to mean all generators of the same type e.g., **V, 0** selects all voltage generators.

NOTE: In this example and in the subsequent examples comma (',') is a separator. It is neither a command nor a part of the command sequence.

Example: **VOLTAGE, 0, EXECUTE.** This sequence of key strokes would select all available voltage generators.

Located at the top of the Control section, this menu incorporates two keys labeled **VOLTAGE** and **CURRENT** which, along with the key labeled **EXECUTE** (located at the bottom of the Control section under the **"OUTPUTS"** menu), select a group of voltage and/or current generators which will be acted upon by other options on the Control section. This selection remains effective until the next selection is made or until a unit **RESET** is executed.

All voltage generators may be freely interchanged among the slots of PULSAR unit without manually adjusting anything in these generators. The same is true

SAFETY PRECAUTIONS

WARNING:
VOLTAGES GENERATED BY THIS INSTRUMENT CAN BE HAZARDOUS

This instrument has been designed for operator safety; however, no design can completely protect against incorrect use. Electrical circuits are dangerous and can be lethal when lack of caution and poor safety practices are used. There are several standard safety precautions that should be taken by the operator. Where applicable, IEC safety markings have been placed on the instrument to notify the operator to refer to the instruction manual for instructions on correct use or safety related topics. Refer to the following table of symbols and definitions.

Symbol	Description
	Direct Current
	Alternating Current
	Both direct and alternating current
	Earth (ground) Terminal. The PULSAR output modules Ground terminals are connected to chassis ground. There is a common chassis ground terminal located on the back panel (see Back Panel under Description of Controls.
	Protective Conductor Terminal
	Frame or Chassis Terminal
	On (Supply)
	Off (Supply)
	Caution, risk of electric shock
	Caution (refer to accompanying documents)

UNDER NO CIRCUMSTANCES SHOULD THE OPERATOR OR TECHNICIAN ATTEMPT TO OPEN OR SERVICE THIS INSTRUMENT WHILE CONNECTED TO A POWER SOURCE. LETHAL VOLTAGES ARE PRESENT AND MAY CAUSE SERIOUS INJURY OR DEATH!

The following are some specific safety related items associated with the PULSAR test system.

Always start with the power OFF, before connecting the power cord. Make sure outputs are off before attempting to make test connections.

Always use properly insulated test leads. The test leads supplied with the unit are rated for the continuous output ratings of the test system, and should be properly used and cared for. Do not use cracked or broken test leads.

Be careful when using the DC Battery Simulator. The DC is on continuously when the power to the test system is on. Make test connections to the device under test prior to connecting the DC Battery Simulator.

Always turn the test system off before disconnecting the power cord or removing / inserting output modules. If removing or inserting modules (output modules, timer modules, etc.) turn unit off, wait several minutes and disconnect the power cord from the test system before removing any module. This allows internal power supply charging voltages to dissipate.

DO NOT power up without module mounting screws and rear thumb screws secured.

⚠ **UNDER NO CIRCUMSTANCES SHOULD THE OPERATOR PUT HIS HANDS OR TOOLS INSIDE THE TEST SYSTEM CHASSIS, OR BACK PLANE AREA, WITH THE TEST SYSTEM CONNECTED TO A POWER SOURCE AND TURNED ON. LETHAL VOLTAGES ARE PRESENT AND MAY CAUSE SERIOUS INJURY OR DEATH!**

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I. THEORY OF OPERATION

A. DESCRIPTION OF CONTROLS

This section of the instruction manual describes the function of all the various controls, switches, push-buttons or keys, alpha-numeric keys, binding posts etc., which are located on the front panel of the AVO Multi-Amp's PULSAR® Universal Test System. All controls and outputs are clearly marked and logically grouped so that continual reference to the instruction manual should not be necessary after the operator has become acquainted with the operation of the test system.

Since the PULSAR design is based on a "modular" concept, the front panel of a PULSAR may vary from unit to unit depending on the modules selected. There are many unique modules or sections a PULSAR may have; Input Power and Control Module, Timer/Monitor and Battery Simulator Module, Voltage Generator Module, Current Generator Module, High Current Interface Module and Blank Module.

Every PULSAR must have the Input Power and Control Module. For testing a relay or for monitoring the response of a device, the Timer/Monitor and Battery Simulator Module is (mandatory) a must. There may be one or more Voltage or Current Modules as required.

1.1 Terminology

There are a few terms and definitions that will be used throughout this manual. A brief description follows.

1.1.1 Procedure

A sequence of front panel key depressions pertaining to the execution of a specific function will be collectively called a procedure.

1.1.2 Procedure Diagram

A procedure diagram is a diagram that is used to explain the correct sequence and content for entering front panel keys for a single function to the PULSAR unit. Such diagrams contain boxes, lines, text, and sometimes arrows.

Horizontal lines without an arrow pointing left that connect boxes (or that connect other lines which eventually connect boxes) indicate logic flow from left to right. Presence of an arrow pointing left indicates logic flow opposite to the default direction.

If a vertical line connects to a line with a left arrow, that vertical line indicates a permissible logic choice only in the direction of that arrow. Other vertical lines that have multiple choices toward the right indicate that each of the choices to the right is logically permissible.

1.1.3 Button Or Key Constants

The contents of certain boxes within procedure diagrams are key constants. A key constant is a set of capital letters and represents a front panel key (except up and down arrow keys, digits, the colon, and the decimal point).

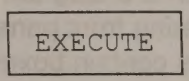
1.1.4 Procedure Variables

A procedure variable is a set of lower case letters that occurs within a box in a procedure diagram. The form and function of each procedure variable is defined in each procedure.

1.1.5 Terminator

A terminator is a final box in a procedure diagram for the front panel of the PULSAR unit. The two valid terminators are the key constant EX (the execute key) and the empty box.

The empty box indicates that the user intends to enter another procedure (function) following this one, and that the user wants this procedure to be executed at virtually the same time as the next procedure. Procedures ending with an empty box are stored until a procedure ending with EXECUTE is received. This allows the cancellation of the effect of a human entry time delay between each pair of procedures in a lengthy string of procedures. All procedures between EXECUTE key depressions will be executed nearly simultaneously. **The empty box is merely a convenience in a procedure diagram; it does not correspond to any key depression.**



A procedure (or string of procedures separated by empty boxes) which ends with an EXECUTE terminator will be executed as soon as it can be processed.

1.1.6 Multiple Choice Symbol

The vertical symbol below is the multiple choice beginning symbol. This shows the starting point for a procedure diagram which has more than one choice for a starting procedure constant.

1.1.7 Shift Key

The numeric keypad area contains two possible functions for each key. The digit usage of these keys is accomplished in a normal fashion. The other (miscellaneous) usage requires, that prior to depressing the target key at its lettered description, one must first depress the shift key. This shift key must be released prior to depressing the target key. The shift key's effect only lasts for the next one keystroke. If that next keystroke is not a key in the numeric keypad area, the prior depression of the shift key is ignored.

1.2 Input Power And Control Module

This module will always be located at the top-left corner of the unit. As mentioned earlier this module is vital to PULSAR operation. This module may be divided into two sections: Power On section (left half) which is devoted to the power on and reset operation of the unit; and the Control section (right half) which allows manual selection of voltage and/or current generator, selection and setting of AC/DC parameters, selection of phase, frequency and range, timer start/stop controls, selection of SYNC parameters, selection of waveforms, outputs on/off etc. A description of each available switch and its operation is described below:

POWER ON/OFF Switch

Vertically located in the Power On section of the module, labeled **1/0**, this switch energizes a PULSAR unit ("1" = ON and "0" = OFF).

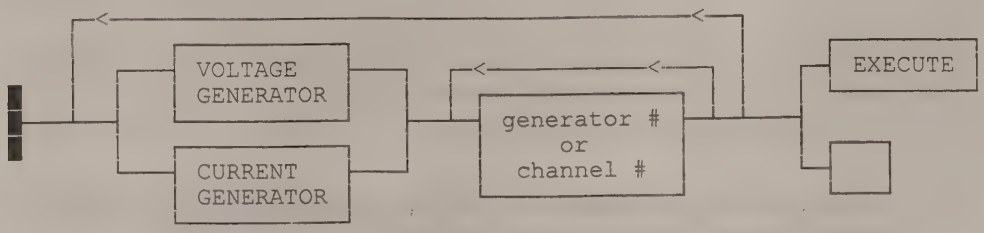
RESET Switch

Located right below the POWER ON/OFF switch, resets the unit to its power-up state without having to power down the entire unit. Use a pencil or a pen to reach and execute. A typical situation when a RESET operation may be required is when there is a "communication lock-up" between a Personal Computer and PULSAR.

CONTROL SECTION

The right half of the module is called the **Control** section. It can be divided into five individual menus which offer the following features:

SELECT/GENERATOR:



where,

VOLTAGE - denotes the **VOLTAGE** key and indicates that a voltage generator is being selected.

CURRENT - denotes the **CURRENT** key and indicates that a current generator is being selected.

generator # or channel # - a single digit in the range of 0 to 9 indicating the generator to be included in this selection.

0 (zero) is pre-defined to mean all generators of the same type e.g., **V, 0** selects all voltage generators.

NOTE: In this example and in the subsequent examples comma (',') is a separator. It is neither a command nor a part of the command sequence.

Example: **VOLTAGE, 0, EXECUTE.** This sequence of key strokes would select all available voltage generators.

Located at the top of the Control section, this menu incorporates two keys labeled **VOLTAGE** and **CURRENT** which, along with the key labeled **EXECUTE** (located at the bottom of the Control section under the **"OUTPUTS"** menu), select a group of voltage and/or current generators which will be acted upon by other options on the Control section. This selection remains effective until the next selection is made or until a unit **RESET** is executed.

All voltage generators may be freely interchanged among the slots of PULSAR unit without manually adjusting anything in these generators. The same is true

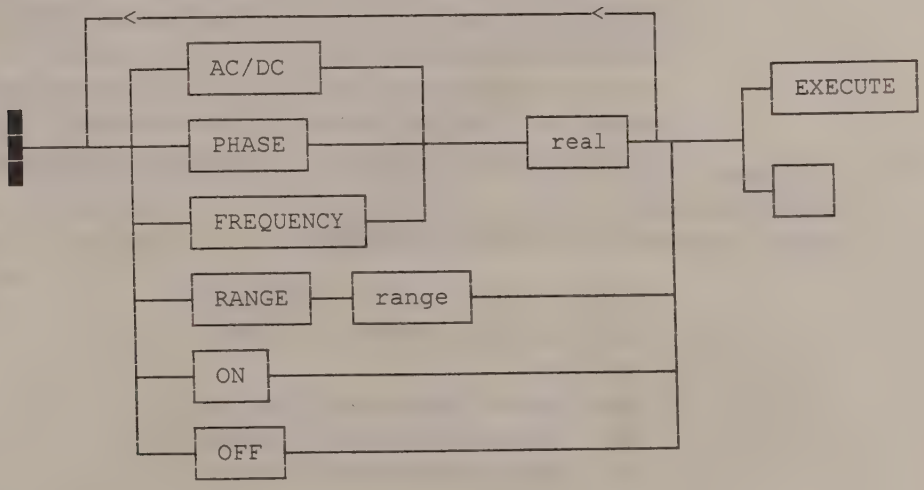
for current generators. The PULSAR unit assigns numbers for identification to the voltage and current generators as follows.

From left to right, top to bottom , the left-most voltage generator is voltage generator number 1. Each successively higher numbered voltage generator is physically positioned to the right of the prior ones. The same scheme applies to the current generators . The left-most generator will either be voltage generator 1 or current generator 1. Voltage and current generators may be interspersed among each other. There may be one or more empty slots between two filled generator slots.

One advantage of this procedure is that either of the keys labeled **"GENERATOR/VOLTAGE"** or **"GENERATOR/CURRENT"** may be keyed immediately after the other one to cancel the effect of the previous key and assert the new one e.g., "**VOLTAGE, CURRENT, 1, EXECUTE**" would select current generator 1 since no number was entered for the voltage generator. Another example - **VOLTAGE, 2, CURRENT, 1, EXECUTE** would select current generator 1 and voltage generator 2. No error beep or flash will accompany such a change.

Example: **"VOLTAGE, 1, CURRENT, 2, VOLTAGE, 3, EXECUTE"**. This sequence of key strokes selects voltage generators 1 and 3 and current generator 2. This could have been entered with "**VOLTAGE, 1, 3, CURRENT, 2, EXECUTE".**

SETTING/AMPLITUDE:



Located right below the **SELECT/GENERATOR** menu is the **SETTING/AMPLITUDE** menu. This menu has six keys labeled **AC, DC,**

PHASE, FREQ, RANGE and **TIMER START**. These keys offer the following features.

AC Selects **AC** output for selected voltage and/or current generators.

DC Selects **DC** output for selected voltage and/or current generators.

PHASE Denotes the **PHASE** key and sets the phase angle (in degrees) of the selected voltage and/or current generators' AC output. PULSAR unit will display the input real number in the range of 0 to 359.9 degrees only. Any angle greater than 359.9 degrees simply wraps around. For example, entering an angle of 600 degree displays 240.

FREQ Denotes the **FREQUENCY** key and sets the frequency of the selected generator(s) in Hertz. However, when the frequency is changed, it will be out of phase until all the generators are shut off or until the **Restore Phase** procedure is executed (more later on **RST PH**). To indicate this condition the generator whose frequency is changed will show dashes at its phase display.

RANGE Denotes the **RANGE** key and sets the range for the selected voltage and/or current generators. The range option is only allowable when the relevant generator is off; otherwise it is a generator range error.

NOTE: The generator range number, which may be zero (automatic ranging) or the maximum number desired in volts or amps, not to exceed 300 in volts or 30 in amps. The PULSAR unit will choose the lowest range which contains the desired value. For example, if 150 volts is selected for a voltage generator, the 300 volt range will be selected. The following ranges are available:

0 - automatic ranging.

300 - Voltage generator: 300 volts.
30 - Voltage generator: 30 volts.

30 - Current generator: 30 amps.
15 - Current generator: 15 amps.
3 - Current generator: 3 amps.

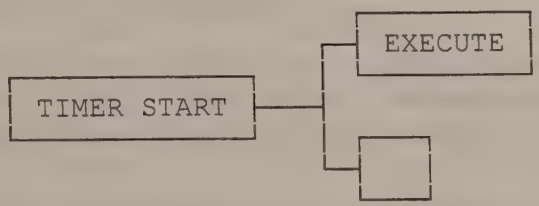
⚠ Application Note: If manually performing dynamic tests (prefault to fault switching) it is recommended that the selected output modules be set to the highest ranges, i.e. 300 volts and 30 amperes.

real - indicates the value of the amplitude, phase, or frequency expressed as a **real** number in decimal form. Allowed values for this variable are:

VARIABLE	RANGE	RESOLUTION
AC Voltage:		
range 300	0 to 300 V_{RMS}	0.02 V_{RMS}
range 30	0 to 30 V_{RMS}	0.002 V_{RMS}
AC Current:		
range 30	0 to 30 A_{RMS}	0.02 A_{RMS}
range 15	0 to 15 A_{RMS}	0.02 A_{RMS}
range 3	0 to 3 A_{RMS}	0.002 A_{RMS}
DC Voltage:		
range 300	-300 to +300 V	0.04 V
range 30	- 30 to + 30 V	0.004 V
DC Current:		
range 30	-30 to +30 A	0.04 A
range 15	-15 to +15 A	0.04 A
range 3	- 3 to + 3 A	0.004 A
Phase	0 to 359.9	0.1 Degree
Frequency	0 to 20 000 Hertz	0.00005 Hertz

TIMER START

Denotes the **Timer Start** key; resets the timer monitor and starts timing at the next depression of the **EXECUTE** key. (For complete operational understanding please see **TSOS** key which defines the term "change of state".)



The timer will stop when the timer stop-gate changes state unless the **TSOS** function is active. The timer monitor may also be started with a change of state of the start binding posts.

Example: **TIMER START, EXECUTE**. Starts the timer immediately.

KEYPAD/SYNCHRONIZATION:

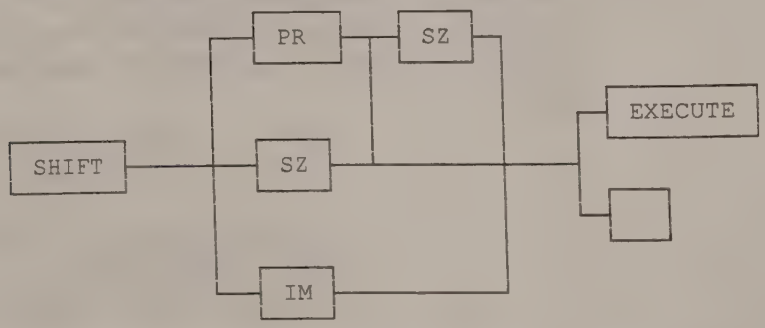
Right below the **SETTING/AMPLITUDE** menu is the alpha-numeric keypad which also offers synchronization features (**SYNC**). Most keys on the keypad have two possible functions. They can be used to enter numeric data in normal fashion. The other function is indicated by the letters printed in the shaded blue letters. These keys require prefix - prior to pressing the target key at its lettered description. This is done by pressing the **SHIFT** key, which is located next to the **OUTPUTS** menu and below the **RAMP** menu.

The **SHIFT** key is not labeled. It is a vertical rectangular box with a blue inset. This **SHIFT** key must be released prior to pressing the target key. The **SHIFT** key's effect only lasts for the next one keystroke.

The following features require the **SHIFT** key as prefix and the **EXECUTE** key as terminator (executor).

SYNC/PR Denotes master **Phase Reference** key and indicates that subsequent procedures will be executed at the master generator's positive zero-crossing phase reference. The generator located in the bottom right-hand slot of the PULSAR is the master generator.

NOTE: The master generator may be set to any desired angle and will not affect the phase reference to other output modules.



NOTE: The master generator is for reference only. It does not have to be set to zero degree, since all angles are relative.

SYNC/SZ Denotes the **SZ (Self Zero)** key and indicates that subsequent procedures will be executed synchronous with each generator's own positive going zero crossing (self zero crossing).

SYNC/IM Denotes the **IM** (**Immediate**) key and indicates that subsequent procedures will be executed **immediately** (point on waveform).

PRSZ Denotes the **PRSZ** (**zero crossing after master phase reference**) keys and indicates that subsequent procedures will be executed at the first zero crossing after the master generator phase reference. **NOTE: PRSZ** is the combination of the keys **PR** and **SZ** which must be pressed sequentially for proper operation.

Example: **SHIFT, PR, EXECUTE** - execute procedures at the master generator's phase reference.

LINE SYNCHRONIZATION

PULSAR was designed to be completely independent of the line voltage and frequency. However, there may be applications where synchronizing to the line frequency may be desirable. PULSAR units built from 1992 to June, 1996 may not have this feature, unless the Input Power Control Module, PN:12189, has been upgraded. With Line Synchronization activated, the output voltages and currents will be in phase with the input power line (± 2 degrees) if the phase setting on the PULSAR outputs is zero degrees. Output settings other than 0 degrees will **Lag** the input power line by the value displayed on the channel. The outputs will stay synchronized as long as the line frequency does not change more than ± 1 Hertz.

1. To switch from the default **Phase Reference** mode to **Line Synchronous**, press the **SHIFT** key followed by the **ON** key. The frequency display on each output module will change from 60.000 (or 50.000) Hertz (indicating internal sync mode) to 60 (or 50) Hertz (indicating line sync mode) .

   Example: **SHIFT, ON, EXECUTE**

2. To return the unit to Internal Synchronization mode, press the **SHIFT** key followed by the **OFF** key. The frequency display on each module will change from 60 (50) Hertz to 60.000 (50.000) Hertz.

   Example: **SHIFT, OFF, EXECUTE**

3. When controlling the PULSAR by a computer, the command **LSI ,** will switch the unit to **Line Synchronous** Mode.

4. Sending the command **LSX,** will turn off the Line Synchronous Mode and return the unit to the Internal Synchronous mode.

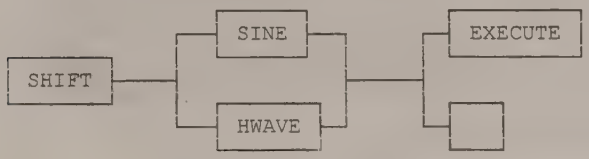
NOTE: After switching to Line Synchronous Mode, allow a couple of minutes for the PULSAR to synchronize to the line. **Reset** of the PULSAR, either manually or by a computer will cause the PULSAR to **return to the Internal Synchronous Mode**.

SINE Denotes the **SINE** key and indicates that a full wave sinusoidal waveform is to be generated by the selected generator(s).

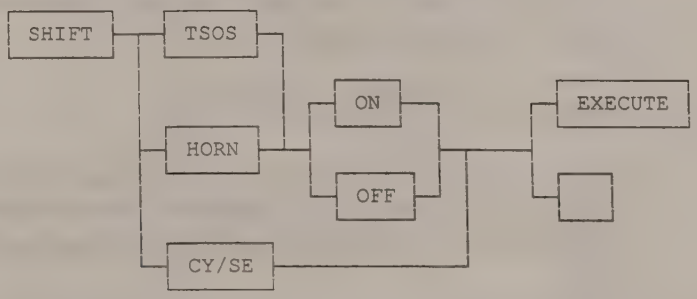
HWAVE Denotes the **HWAVE** key and indicates that a position **half-wave** sine wave is to be generated by the selected generator(s).

Example: **SHIFT, HWAVE EXECUTE** - the previously selected generators will generate a half-wave sinusoidal waveform.

NOTE: The selected generator(s) HERTZ display will be a dashed line indicating that the output will be a half-wave, until reset or the SINE function is selected.



The following three features **HORN, CY/SE** and **TSOS** are not functional if the PULSAR unit does not contain a Timer-Monitor module.



HORN Denotes the **HORN** key and indicates a start timer horn or a stop timer horn function. The **ON** and **OFF** keys from the **OUTPUTS**

menu must follow the **HORN** key in order to activate and deactivate the timer horn.

Example: **SHIFT, HORN, ON, EXECUTE.** This key sequence will turn the HORN on in association by the MONITOR (continuity).

CY/SE Denotes the **CY/SE** key (**CYcles/SEconds**) and indicates that the display output of the timer is toggled between cycles and seconds. In cycles mode an automatic division of the number of seconds by the period is performed. The period is known from the internal jumper selected frequency (50 or 60 Hz). In seconds mode the display output is in seconds. The default is seconds.

TSOS Denotes the **TSOS** (**T**imer **S**top **O**n **S**ynchronization) key and indicates that if the **ON** (located under **OUTPUTS** menu) key is pressed next:

the timer start gate will be activated when there is a change of state. A change of state occurs when an input binding post changes from:

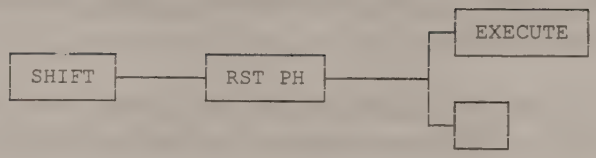
(a) continuity to no continuity;
(b) no continuity to continuity;
(c) voltage applied to voltage removed;
(d) no voltage applied to voltage applied.

Example: When testing an auto-synchronizing relay, the Timer will start when the relay closes its contacts at the advanced angle.

the timer stop gate will be activated when the two selected generators are synchronized (for the above example, the time indicated should be the closing time of the breaker).

If the **OFF** (under **OUTPUTS** menu) key is pressed next after the **TSOS** key, this function is canceled.

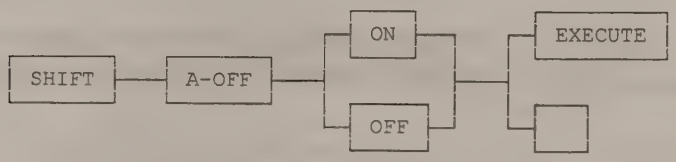
RST PH Denotes the **RST PH** key; restores the phase relationship of all generators. When the frequency of a generator is changed, its phase relationship to the other generators will be unpredictable. To indicate this condition the generator whose frequency is changed will show dashes at its phase display. The phase will be restored when **RST PH** is executed.



The restoration of phase will occur at the next zero crossing of the master generator. Phase is automatically reset whenever all voltage and current generator outputs are off.

Example: **SHIFT, RST PH, EXECUTE** - restore the phase relationship of all generators.

A-OFF Denotes the **A-OFF** (auto off) key and allows the user to have all outputs turned off whenever the stop gate of the timer-monitor changes state.



If used with the **ON** key, indicates that the **A-OFF** (AUTO OFF) function is in effect. And, if used with the **OFF** key, indicates that the **A-OFF** function is canceled.

Example: **SHIFT, A-OFF, ON, EXECUTE** - turn off all outputs whenever the timer changes state.

OUTPUTS MENU:

Directly below the alpha-numeric keypad is the **OUTPUTS** menu which offers the following items:

ON The primary function of the **ON** key is to control the voltage and/or current outputs. This key, along with the **EXECUTE** key turns selected generators' output (both AC and/or DC parameters) on.

It may also be used after the **TSOS** key or the **HORN** key. Its use for the **TSOS** key has been explained earlier (see **TSOS**). For **HORN** key it indicates a timer horn enable, which applies to both start timer horn and stop timer horn. When enabled, the horn will sound whenever the timer input binding posts have voltage applied and/or continuity.

Can also be used with the **A-OFF** key (see **A-OFF**) to enable the auto off function throughout a certain operation.

OFF The **OFF** key also controls the outputs of different PULSAR modules. Along with the **EXECUTE** key it turns off the outputs of selected generator(s).

It may also be used after the **TSOS** key or the **HORN** key. Its use for the **TSOS** key has been explained earlier (see **TSOS**). For **HORN** key it indicates a timer horn disable which applies to both start timer horn and stop timer horn. When disabled, the horn will be disconnected from the timer input binding posts.

Can also be used with the **A-OFF** key (see **A-OFF**) to disable or cancel the auto off function throughout a certain operation.

EXECUTE This key allows immediate execution of function(s). Any string of allowable and applicable keys that were pressed prior to pressing the **EXECUTE** key is executed immediately.

CANCEL Denotes the "**CANCEL**" key and it allows the cancellation of all entered procedures since the previous **EXECUTE** key was depressed. It works in conjunction with the **SHIFT** key i.e., it requires the **SHIFT** key as prefix. If no procedures were entered via keys since the last **EXECUTE** key was pressed, this function does nothing. If this function is entered more than once consecutively, it accomplishes no more than if it were entered once.

This procedure is unique in that it is executed immediately, i.e., without waiting for a subsequent execute key or the start of a subsequent procedure.

RAMP MENU:

Located directly above the **SHIFT** key are the **Ramp** keys which allow the user to ramp up or down any selected output(s) that include AC/DC voltage, current, phase angle and frequency. It incorporates four up-arrow keys and four down-arrow keys that cause the previously selected generators to increment (if up-arrow) or decrement (if down-arrow) at the selected increment or decrement rates.

The increment or decrement values vary depending on what is being ramped and what range the output is set for.

When incrementing the amplitude or the phase angle, the top-most up-arrow key increments the most significant digit and the bottom-most up-arrow increments the least significant one. When incrementing, the bottom-most down-arrow key decrements the most significant digit and the top-most down-arrow key decrements the least significant one. The size of increment or decrement is

determined by the **RANGE**. The ramp rate is set to 2 digits per second. For example, the amplitude of the current channel may be ramped in increments of 2 (top-most up-arrow), .2 (second up-arrow from top), .02 (third up-arrow from top) or .002 (fourth up-arrow from top or the bottom up-arrow) amperes/second in the 3 amp range.

1.3 Timer-Monitor And Battery Simulator Module

The Timer-Monitor and Battery Simulator Module is designed to slide into or out of the PULSAR unit. It contains the programmable trigger inputs for the START, STOP, or CONTINUITY gates, banana plug receptacles, TIMER, an auxiliary programmable dry contact and Battery Simulator option of 48, 125 and 250 volts dc.

The Timer is specifically designed to measure high speed operation of electro-mechanical, solid-state and microprocessor-based protection relays. In addition, it will also perform timing tests on EHV to low voltage breakers, trip circuits and contactors. It incorporates three sets of banana plug receptacles, which can be programmed to be; Start, Stop Gates and Monitor, or all Stop Gates, or all Contact Continuity Monitors.

The programmable auxiliary contact may be programmed for a normally open or normally closed by software command, refer to PULSEMASTER instruction manual.

The Battery Simulator has four terminals providing three voltages 48, 125 and 250 volts dc. The primary application is to provide dc logic voltage to solid-state and microprocessor relays.

The features of the **TIMER-MONITOR AND BATTERY SIMULATOR MODULE are described in detail**:

TIMER Display — Indicates elapsed time either in seconds or in cycles. The TIMER is set either by software command, refer to PULSEMASTER manual, or by the keypad with the following commands **SHIFT, CY/SEC, EXECUTE** and the TIMER display will indicate SECONDS or CYCLES.

START, STOP, MONITOR Gates — Three identical, independent, programmable START (top binding posts Terminal 1), STOP (middle binding posts Terminal 2) or MONITOR (bottom binding posts Terminal 3) gate circuits permit simple selection of the desired mode of timing or contact monitoring operation. To monitor operation of the contacts or trip SCR in the device under test, a continuity "ACTIVE" light is provided for each gate. The

gate circuit is isolated for voltage-sensing and can monitor solid-state logic signals. Upon sensing continuity or a voltage signal the "ACTIVE" lamp will glow and (if desired) a tone generator (horn) will sound. The power-up default states for the START/STOP and MONITOR gates are CONTINUITY, Change of State (Normally Open, N.O. closing or Normally Closed, N.C., opening). To change a gate to VOLTAGE, Change of State (Voltage Applied, Voltage Removed) see the following example. Example; change Timer Stop (Terminal 2, second set of terminals) to VOLTAGE, Applied. Use the following key strokes, **SHIFT, TIMER START, 2, EXECUTE**. The LED indicator should toggle from CONTINUITY to VOLTAGE. NOTE: To toggle back, repeat the above key strokes. The following modes are provided for the Start/Stop/Monitor Gates:

a) Dry Contacts Open - timer starts, stops or continuity indicator glows at the opening of normally closed contacts or when conduction through a semiconductor device such as a triac or a transistor is interrupted.

b) Dry Contacts Close - timer starts, stops or continuity indicator glows at the closing of the normally open contacts or upon conduction through a semiconductor device such as a triac or a transistor.

c) Application or Removal of ac or dc voltage timer starts, stops or continuity indicator glows (application) or darkens (removal) upon the application or removal of either an ac or dc voltage. The voltage threshold is adjustable by turning the small pot located between the Red and Black binding posts from 1 to 4 volts, ac or dc positive going signal. A higher threshold voltage helps to eliminate false triggers due to noisy source. Lower thresholds allow starting and stopping of timer from TTL voltage signals. The maximum allowable voltage applied is 300 volts AC or 300 volts DC, limited by MOV transient protection.

d) Starting or stopping with any selected generator module. The Timer can be started or stopped when turning on or off any (or all) selected generators.

e) The Timer can be started simultaneously with a change in Frequency, Phase Angle, Amplitude or a waveform (voltage or current) step.

f) The Timer can be stopped upon Phase Synchronization between two voltage channels (normally used to time auto synchronization relays, see Operating Procedures, Testing Auto-Synchronizing Relays).

CONTINUITY/VOLTAGE Indicator

To manually to toggle between CONTINUITY (N.O./N.C. Dry Contact Change of State) and VOLTAGE (AC/DC Applied/Remove Change of State) for any of the Timer Start/Stop/Monitor gates use the following example.

Example: **SHIFT, TIMER START, 3, EXECUTE** - Will toggle the Timer Terminal 3, (MONITOR gate is default for Terminal 3) from CONTINUITY to VOLTAGE.

To change from VOLTAGE back CONTINUITY, repeat the commands reverses the condition.

Application: Stop Timer when DC voltage applied. The default setting of the Timer Stop (Terminal 2) is CONTINUITY. Press **SHIFT, TIMER START, 2, EXECUTE**. Terminal 2 changes to VOLTAGE Applied/Remove.

START LATCH

When selected "LATCHED", the Start Latch allows timing to be initiated by a Start Gate and to be stopped only by the selected Stop Gate. When "UNLATCHED", the Start Latch allows timing to be stopped when the Start Gate is reversed (such as when timing the closing and opening of a single contact as in measuring the trip-free operating time of a circuit breaker.

STOP LATCH

When "LATCHED", the Stop Latch allows timing to be stopped at the first operation of any Stop Gate (thus ignores contact bounce). When "UNLATCHED", the Stop Latch allows timing to be stopped by any Stop Gate and then restarted if the Stop Gate reverses (provided a Start Gate is still energized), and then stopped again when the gate reverses (total time including contact bounce).

TIMER Reset

The Timer is defaulted to automatically reset when the **TIMER START, EXECUTE** Keys are pressed. Should it be desired to Reset the Timer due to change of the Time Start/Stop terminals (i.e. change from Normally Open, N.O., to Normally Closed, N.C.) condition, then the operator will need to manually reset the Timer using the following key strokes, **SHIFT, 6, EXECUTE**. NOTE: The number 6 key does not have a Blue Function shown. Think of it as the Timer Reset function key.

START/STOP GATE DE-BOUNCE

The timer can be programmed to ignore temporary state changes that are less than a programmable duration. This is useful for eliminating false triggering and contact bounce errors.

De-bounce Period: 0 to 999 milliseconds.
Resolution: 0.1 ms.

AUXILIARY CONTACT

A pair of banana receptacles provide access to the programmable dry contacts. The contacts may be opened or closed by software command, refer to the PULSEMASTER instruction manual.

Maximum Switching Voltages: 110 volts AC or 30 volts DC.

Maximum Switching Currents: 0.3 amps AC or 1.0 amps DC.

Opening Time: 0.5 ms typical.
Closing Time: 1 ms typical.

BATTERY SIMULATOR

Four banana plug receptacles provide the following voltages 48, 125 and 250 volts dc. Only one output voltage may be used at a time. The maximum output power is 60 watts.

NOTE: dc voltage is ON and available when PULSAR is turned on by the ON/OFF switch. Do not plug or insert any test lead into the BATTERY SIMULATOR binding posts without first connecting the test leads to the load!

1.4 Voltage Generator Module

The Voltage Generator Module is also designed to slide into or out of, a single PULSAR module slot. **One module can provide either ac or dc voltage** output of 0 to 30 $volts_{RMS}$ or 0 to 300 $volts_{RMS}$.

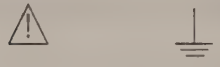
VOLTS Display — This four digit LED display indicates the amplitude of the voltage output.

DEGREES Display — This four digit LED display indicates the phase angle of the voltage output in positive phase rotation angles. Where V_1 is 0.0°, V_2 is 120.0°, and V_3 is 240.0° (V_2 lags V_1 by 120.0° and V_3 leads V_1 by 120.0°).

FREQUENCY Display — This five digit LED display indicates the frequency of the voltage output. For DC voltage the display will show zero.

STATUS Display — Located right below the Frequency display is the STATUS display, which displays output status (on or off) and DC offset when applicable.

Red and White Voltage Binding Posts



Provides for connection to voltage output. The White binding post is grounded and should be used as the instantaneous non-polarity terminal with the red terminal as polarity. The ground (earth) terminal is connected to the chassis ground.

Error Indication and Alarm — Circuitry is incorporated to indicate whenever the amplitude, phase angle, and/or waveform of the voltage source is in error. When an error is detected, the amplitude display will flash and the alarm will sound.

1.5 Current Generator Module

The Current Generator Module is also designed to slide into the PULSAR unit. Each current module takes up two slots of a PULSAR unit. **One module can provide either ac or dc current output**, 0 to 3 amperes, 0 to 15 amperes or 0 to 30 amperes.

AMPERES Display — This four digit LED display indicates the amplitude of the current output.

DEGREES Display — This four digit LED display indicates the phase angle of the current output.

FREQUENCY Display — This five digit LED display indicates the frequency of the current output. For dc current the display will show **dc**.

STATUS Display — Located right below the Frequency display is the STATUS display, which displays output status (on or off) and DC offset when applicable.

Black and White Current Binding Posts

Provides for connection to current output. The White binding post is grounded and used as the instantaneous non-polarity terminal with the Black terminal as polarity. The ground (earth) terminal is connected to the chassis ground.

Error Indication and Alarm — Circuitry is incorporated to indicate whenever the amplitude, phase angle, and/or waveform of the current source is in error. When the error is detected, the amplitude display will flash and the alarm will sound.

1.6 High Current Interface Module

The High Current Interface Module is designed to slide into the PULSAR unit. Each Module takes up 1 slot of the unit. See installation instructions below. The Module is designed to interface with the AVO Multi-Amp Models EPOCH-20 or EPOCH-II, High-Current Output Units (see EPOCH-20 or EPOCH-II Bulletins for output specifications). This module provides control of the EPOCH-20 or EPOCH-II current amplitude, phase angle and frequency output. Status of the EPOCH-20/II output can be seen on the front panel display.

AMPERES Display — This four digit LED display indicates the amplitude of the current output.

DEGREES Display — This four digit LED display indicates the phase angle of the current output.

FREQUENCY Display — This five digit LED display indicates the frequency of the current output.

NOTE: The EPOCH-20 or EPOCH-II output frequency is limited to 5 Hz. (lowest output frequency). The output compliance voltage and Volt-Ampere output is derated linearly to 50 % of specification from 40 Hz. to 20 Hz.

INSTALLATION

To install the interface module may require the removal of another output module, see Section F, REPAIR DATA, Removal of Current Amplifier Module for instructions to remove the output module from the chassis. Since the current output module takes up two slots and the interface module only uses one, a blank module is required to fill the void slot. If the interface module was ordered separately, then it is provided with a blank module.

WARNING: The blank module must be installed in the empty slot prior to operating the unit, since **dangerous high voltage is present on the inside back plane connector**.

NOTE: Remove Current Output Module #1 for use with PulseMaster software.

To install the interface and blank modules, carefully slide the modules into the chassis. Make sure they are properly seated into the back plane connectors by pressing firmly on the front of the module. Screw back panel knurl knobs onto the interface and blank modules. Reinstall front panel screws.

Hardware interface connections are made on the back of each unit using the interface cable provided in the accessory kit. The cable connectors fit the EPOCH-20 interface connectors. An adapter connector mates with the interface cable to connect to the EPOCH-II signal INPUT connector.

OPERATION

Turn **ON** the PULSAR, all current and voltage modules except for the EPOCH-20/II **HIGH CURRENT INTERFACE MODULE** will display zeroes and system frequency. The high current module will have dashed lines (- - - -) in the amperes display. Turn ON the EPOCH-20/II test set then press the **Reset** button on the PULSAR, the dashed lines will be replaced with zeroes. The unit is now ready to use. Refer to the EPOCH-20/II Instruction Manuals for proper operation.

When a relay test is completed and the **HIGH CURRENT INTERFACE MODULE** is no longer required, turn **OFF** the EPOCH-20/II test unit. If a DC target test is required and if you are using PulseMaster, with the EPOCH-20/II off (EPOCH-20/II cannot provide DC current, but PULSAR current modules can) press the **Reset** button on the PULSAR. This will cause PULSAR to default to the second current module. The test can now be conducted.

The **HIGH CURRENT INTERFACE MODULE** can be left in the left most slot until further needed. The second and third current modules can be used to do other relay testing. When using PulseMaster, always remember to press the **Reset** button on the PULSAR before accessing another high current relay test file.

1.7 Back Panel

The input line cord, ground terminal, interconnecting plugs, and RS-232C port are mounted on the back panel of the test set. The following is a description of each item.

Input Line Cord

The test set is equipped with a suitable line cord which is part of the accessory kit, it connects to the male plug on the back panel. Verify input voltage before connecting the line cord to the source of power. **NOTE:** Unit can be powered up from an input source with a rating of 95 Vac to 265 Vac. PULSAR can automatically select (or adjust to) the available power if it is within the specified range mentioned above.

Unit is equipped with an internal fuse.

A chassis ground (earth) point on the back panel is provided as an additional safety ground. A ground is provided at the input power connection.

IEEE-488 GPIB (Optional) Bus Connection

The optional General Purpose Interface Bus (GPIB) enables the PULSAR to function as a talker-listener with any controller or computer which conforms to the IEEE-488 Bus connector.

The significant benefit for having this option will enables the user to download DFR and EMTP files faster than using the RS-232 port.

SERIAL INTERFACE

Provides communication port for control by computer. PULSAR requires a straight 9 pin, female to female communication cable. See Appendix A for PULSAR Remote Operation Command Set and communication protocol.

SYNC IN

Used with the Sync Out from another PULSAR unit or other TTL (+ 5Vdc) signal source (Trigger from a GPS satellite receiver). Primarily used to trigger an operation or programmed event.

SYNC OUT	Used to provide a TTL signal to another PULSAR unit for multiple box operation.
CLOCK IN	Used with the Clock Out from another PULSAR unit or other Clock Source for special testing applications. Normally used for multiple box operation to phase lock.
CLOCK OUT	Used to provide a 214.7 Khz clock signal to another PULSAR unit for phase locking multiple boxes.
EXPANSION INTERFACE	Provided for future expansion and special applications.
Analog Connectors	Each output module has a 3 pin, female, mini-DIN connector. An analog signal of ± 5 Vpeak = Full Scale output. **CAUTION:** Do not exceed ± 5 Vpeak! Do not apply a square wave with a 5 Vpeak. To do so will cause damage to the amplifier. If square waves are required, it is recommended that 3.5 to 4 Vpeak not be exceeded. Contact factory for details regarding pin connections.

B. INITIAL SET-UP

Unpack the unit and check for any evidence of shipping damage. If visual damage is present, notify freight carrier to make damage claims. Also, notify the factory. The covers are easily removable for access to the front and back panels.

⚠ **CAUTION**

Potentially lethal voltages can be present on the output terminals. It is recommended that the operator thoroughly read the instruction manual and understand the operation of the test set before energizing. An operational check may be performed as follows to verify that the amplitude, phase angle and monitor circuits are functioning properly.

1. Before plugging in the unit, make sure the POWER ON/OFF Switch is OFF.

2. Plug the line cord for the test set into a suitable source of power and switch the POWER ON/OFF Switch ON.

3. It is recommended that all the current and voltage amplitudes and phase angle controls be checked using external instrumentation before placing unit in service.

SELECTION OF MASTER MODULE

When the unit comes from the factory, there will be a generator module (either current or voltage) in the lower right-hand corner of the unit for **phase synchronization.** If you want to change the configuration (i.e., re-arrange the placement of the modules) **you must have a module in the lower right-hand corner slot**, see DESCRIPTION of CONTROLS, SYNC/Phase Reference.

C. OPERATING PROCEDURES

Introduction

After thoroughly reviewing the theory of operation section of this instruction manual, the operator should have a good understanding of the operation of PULSAR.

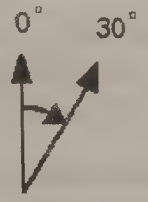
Use of PULSAR

This section describes basic operating procedures for using the multiple output modules of the PULSAR Test Set for such applications as paralleling current outputs, conducting harmonic restraint tests, series of potential sources to provide higher than rated potential, testing over/under voltage relays and forming three phase voltage outputs.

1.0 Setting Phase Angle Relationships

Think of each PULSAR module as a vector generator. Each module has an internal zero reference to which it references its phase angle settings, as displayed on the LED readouts. This applies to phase angle settings between the voltage and current modules of a PULSAR. When setting a phase angle between two modules of a PULSAR unit, it is recommended that one module be set at zero degree and the other module be referenced to that module at zero degree. This is for operator convenience and reduces confusion. When setting an angle, the operator has a choice of setting the angle either in the

CLOCKWISE or COUNTERCLOCKWISE direction. Pressing the up-arrow keys on the key-pad increases the phase angle in the clockwise direction from 0.0 to 359.9 degrees. For example, setting an angle of 30 degrees between two modules would vectorially look like ....



The reference output is 0 degree and the second module is rotated 30 degrees clockwise or **lagging** the referenced source by 30 degrees.

NOTE: All phase angles displayed on PULSAR are lagging phase angles.

Conversely, if the second module were set by pressing the down-arrow keys, the angle decreases in the counterclockwise direction from 359.9 to 0.0 degrees. For example, setting an angle of 300.0 degrees on the second module would vectorially look like . . .

The reference module is 0 degree, and the second module is rotated to 300 degrees in the counterclockwise direction, which is to say that the second module still lags by 300 degrees or leads the reference module by 60 degrees.

1.1 Current Sources-Parallel Operation

When the current source voltage available from a single PULSAR current channel is insufficient to push higher than rated current from any tap, two or three current channels may be connected in parallel to provide the additional current capacity. To parallel the current channels of the PULSAR test set, proceed as follows:

1. Using the current channel test leads, connect each current channel to the relay under test. **The parallel connection must be made at the relay not at the source**. Also, note that all current sources White binding posts are grounded.

2. Switch PULSAR ON.

3. Set the current channels to be used in parallel such that for using two current channels the settings between the two outputs will be one-half and the settings between three current channels will be one-third. Initiate all of the PULSAR current channels together by pressing the following keys **CURRENT, 0, ON, EXECUTE**. All parallel current outputs must be ON to prevent internal shunting of current.

   NOTE: All current channels should be set to the same phase angle.

4. All current channels amplitude control now operates simultaneously to provide the desired test current. Total output is the sum of the current displayed on the current channels amplitude display.

1.2 Current Sources-Harmonic Restraint Test

NOTE: To obtain the desired current output necessary to conduct harmonic restraint tests on differential relays, two PULSAR current channels must be used, one current channel will provide the harmonic output and the second current channel will provide the fundamental or "*by-pass*" current.

There are two methods available in PULSAR to do harmonic restraint tests. One method uses a pure harmonic (2nd, 3rd, 5th, etc) of the fundamental from one current channel, summed with the fundamental current from a second current channel at the relay. The second method uses the PULSAR "HWAVE" feature. The HWAVE simulates the "diode method" recommended in some relay manufacturers instruction literature. When the HWAVE is selected, the selected output module will provide a "half-wave" sinewave (similar to what you would see if using a diode in series with a current source).

NOTE: Most recommended test procedures suggest using 4 amperes DC of half-wave. Since PULSAR displays the full RMS sine-wave quantity, it will be necessary to set 8.89 amperes RMS on the selected HWAVE current channel in order to get the desired equivalent 4 amperes DC half-wave. To calculate other values of DC half-wave use the following formulas,

Idc (half-wave) = Ipeak / π and Ipeak = Irms * 1.414

Therefore, Idc (half-wave) = Irms * 1.414 / π

or, Irms = Idc (half-wave) / 0.45

Solving, Idc = 4

Irms = 4 / 0.45

Irms = 8.89

To set up the PULSAR for harmonic restraint testing, use the following procedure:

1. Switch the POWER ON/OFF Switch ON.

2. Select one of the current modules to provide the desired harmonic. Set the current channel to the desired harmonic either second, third, or fifth in conjunction with the FREQ. selector switch. For example, use the following keystrokes to set Current Channel #2 to the second harmonic of 60 Hz; **CURRENT, 2, FREQ, 120, SHIFT, RST.PH., EXECUTE**. If using the HWAVE feature set; **CURRENT, 2, SHIFT, HWAVE, EXECUTE**.

3. Connect a pair of current output leads from two of the PULSAR current channels to the relay, so that current from each output will be in parallel with one restraint and the operating coil of the relay. Check to insure both commons (grounds or earths) share the same relay terminal.

4. Initiate the outputs. The output "**ON**" light should be displayed on the current amplifier front panel.

5. Increase the output to the appropriate harmonic current. It is recommended that one ampere of harmonic current be set (it will make the math easier). If using the HWAVE, set the displayed current to 8.89 amperes RMS (this equals 4 amperes DC half-wave).

6. Increase the fundamental current until the relay operates. To calculate the percent of harmonic restraint use the appropriate equation below (if using pure harmonic current). If using the HWAVE refer to the manufacturers instruction literature for the appropriate % Harmonic Curve.

   Type BDD

$$\%_{Harmonic} = \frac{2_{nd}\ Harmonic\ Current}{\sqrt{(Fundamental)^2 + (2nd\ Harmonic)^2}} \times 100$$

Type HU

$$\%_{Harmonic} = \frac{1.2267 \times 2_{nd}\ Harmonic\ Current}{\sqrt{(Fundamental)^2 + (2nd\ Harmonic)^2}} \times 100$$

NOTE: **If you used the HWAVE feature**, after completion of the test, **restore the HWAVE channel to a sine wave** by pressing **CURRENT, 0, SHIFT, SINE, EXECUTE**.

1.3 Voltage Sources - Outputs Summed Together

Two PULSAR voltage channels may be used to sum voltage outputs to obtain higher than rated voltage provided the load is not grounded. Simply connect the load between two Red binding posts of the voltage channels, set V_1 Phase to 0 degrees and set V_2 Phase to 180 degrees. The voltage outputs will now add and the voltage amplitude will be the sum of the two voltage amplitudes displayed on V_1 and V_2 amplitude displays. Note that the White common terminals are grounded and are not used.

1.4 Voltage Sources - Dynamic Voltage Relay Test

Over/Under Voltage Relays can be dynamically tested using one voltage channel of the PULSAR test set along with the internal timer. This procedure applies a "*normal*" voltage to the relay under test and then automatically adjusts the test voltage to a "*fault*" amplitude either higher for testing over voltage relays or to a lower voltage for testing under voltage relays. Additionally, the timer is automatically started with "*fault*" voltage applied to the relay under test.

First, set the "normal" voltage on the relay. For example, **VOLTAGE, 1, AC, 120, ON, EXECUTE**. Then, with the relay energized to normal condition, set the desired "fault" voltage and Timer Start (relay trip circuit should be connected to the Timer Stop terminals). If you want to de-energize the voltage to the relay when it trips, use the Auto-Off feature. For example, setting a "fault" voltage of 87 volts with Auto-Off the commands would be: **AC, 87, TIMER START, Shift, A-OFF, ON, EXECUTE**. The 87 volts will be applied, the Timer will Start, the relay trips, stops the Timer and turns the outputs OFF.

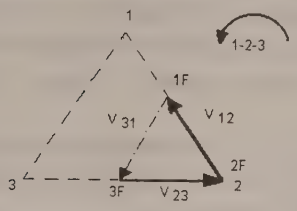
1.5 Voltage Sources - 3Ø, 3-Wire, Open-Delta and T-Connection

Open Delta Two methods of obtaining three-phase, three-wire voltage source are available. The Open-Delta configuration (shown in Figure 1) is the easier to use when a balanced three-phase source is required because the amplitude and phase relationship can be set directly. No calculations are necessary.

When using the Open-Delta Configuration to set up a phase-to-phase fault, calculations using the Law of Cosines is required to calculate amplitude and phase relationships. (See discussion under T-Connection for simulating unbalanced, phase-to-phase faults without need for calculations.)

When using the Open-Delta configuration, it is suggested the voltage channel #1 Red binding post is designated V_1, voltage channel #2 Red binding post is designated V_3, while either White COMMON binding post is designated V_2. With this arrangement, the magnitude and phase angle of the potentials can be easily calculated and set. For the balanced three-phase condition V_{12} and V_{23} are equal in magnitude and separated by an angle of 60°. This is done by setting the V_1 and V_3 potentials equal in magnitude, setting 0 degrees on V_1 and 300° (60 degrees leading) on V_3, (see Figure 1).

FIGURE 1
BALANCED 3Ø - 3 WIRE FAULT
OPEN DELTA CONNECTION



If V_f = Desired Test Potential

Set $V_1 = V_f \angle 0^\circ$

Set $V_3 = V_f \angle 300^\circ$

Voltage Output Connections

When setting up an unbalanced Open-Delta configuration, the desired phase-to-phase fault voltage, V_{12} is set using voltage channel #1 and its phase angle is set to 0 degrees. Phase-to-phase voltage V_{23} and its phase angle relationship for voltage channel #2, must be calculated using the Law of Cosines; where $V_B^2 = (V_A^2 + V_C^2) - 2_{AC}$ cos B.

Figure 2 shows the phase relationships and an example of the necessary calculation. For user convenience, the amplitude and phase angle settings for typical V_f fault magnitudes are tabulated.

T-Connection The second method of obtaining three-phase, three-wire 0 voltage source is the T-Connection. This method as shown in Figure 3 is easier to use when obtaining an unbalanced, phase-to-phase fault simulation because it eliminates

calculations. To reduce confusion when using the T-Connection, it is suggested that voltage output #1 be designated V_a and its phase angle set at 0 degrees, voltage output #2 be designated V_b and its phase angle set for 180 degrees and voltage output #3 be designated V_c and its phase angle is set for 270 degrees; any combination of balanced 3Øf or unbalanced Ø - Ø fault conditions can be easily simulated. Figure 3 shows the phase relationships.

NOTE: This method is not good for very low fault voltages, i.e., 5 volts or less, or for testing ABB (WESTINGHOUSE) type SKD relays.

1.6 Voltage Source - 3Ø, 4-Wire, Y-Connection

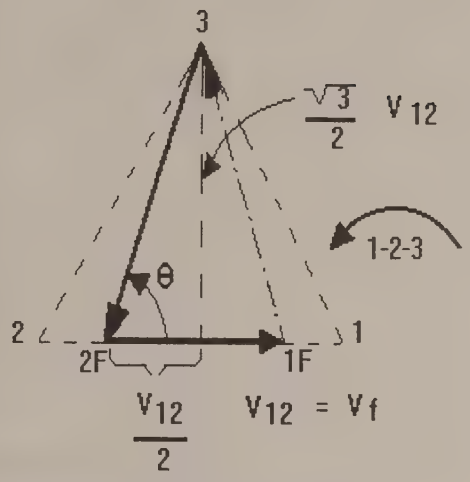
A three-phase, four-wire potential system can be provided using three output modules. The vector relationships are shown in Figure 4. This Y-Connection has the advantage of being able to supply higher line-to-line voltage (1.73 x phase-to-neutral voltage) and is ideally suited for simulating phase to ground faults. Voltage channel #1 is designated as V_a with its phase relationship set for 0 degrees. Voltage channel #2 is then designated as V_b and phase angle set for 120 degrees. Finally, voltage channel #3 is designated V_c and phase angle set for 240 degrees (for a 1-2-3 counter clockwise rotation). V_a, V_b and V_c are then connected to the Red potential binding posts on the respective test sets. If a neutral is required, it is connected to a White potential section binding post on any voltage output module to ground the load.

FIGURE 2
OPEN DELTA CONNECTION
UNBALANCED - Ø TO Ø FAULT

FROM LAW OF COSINES

$$\theta = \arccos\left(\frac{V_{12}}{2} V_{23}\right)$$

$$V_{23}^2 = \left(\frac{V_{12}}{2}\right)^2 + \left(\frac{\sqrt{3}}{2} * 120\right)^2$$



NORMAL BALANCED CONDITION

V 12 = V 31 = V 23

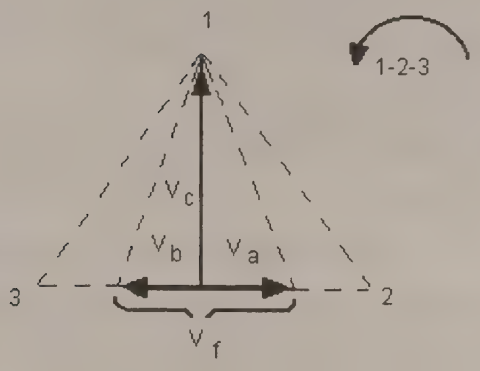
Settings For Typical Fault Voltages

$V_{12} = V_f$

V_{12}	1	5	10	15	20	25	30	35	40	45	50	55	60	65	70
V_{23}	104	104	104	104	104	105	105	105	106	106	106	108	108	109	110
At θ° Lag	270	271	273	274	275	277	278	280	281	282	284	285	286	287	289

Voltage Output Connections

FIGURE 3
BALANCED OR UNBALANCED FAULT
T-CONNECTION



V_f = *Desired Fault Voltage*

$V_a = \frac{1}{2} V_f \angle 0°$

$V_a = \frac{1}{2} V_f \angle 180°$

$V_c = \frac{\sqrt{3}}{2} 120$ *or* $V_c = 104V \angle 270°$

Voltage Output Connections

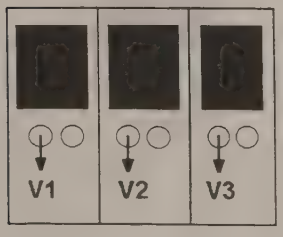
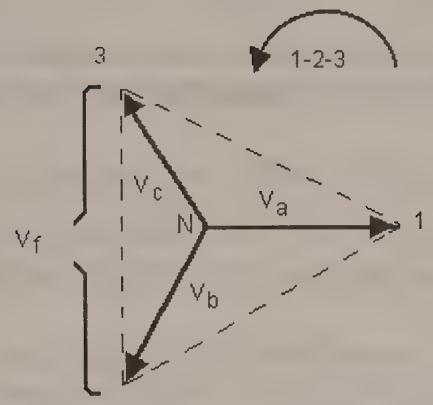


FIGURE 4
BALANCED 3 Ø
4 WIRE Y CONNECTION



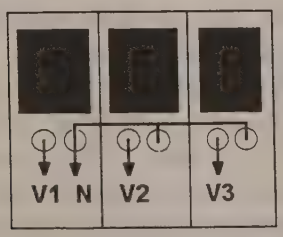
V_f = *Desired Fault Voltage*

$$V_a = \frac{\sqrt{3}}{3} V_f \angle 0°$$

$$V_b = \frac{\sqrt{3}}{3} V_f \angle 120°$$

$$V_c = \frac{\sqrt{3}}{3} V_f \angle 240°$$

Voltage Output Connections



1.7 Manual example for setting up a 3-phase WYE relay test.

1.7.1 Connect relay contacts to the monitor gate and energize the audible tone generator by selecting the

[SHIFT] [HORN] [ON] [EXECUTE]

Assuming all voltage and current tests leads are applied to the relay, to apply a 3-phase voltage of 67 volts 120° separation the following commands are necessary.

[VOLTAGE] [0] [AC] [6][7] [VOLTAGE] [2] [PHASE] [1][2][0]

[VOLTAGE] [3] [PHASE] [2][4][0] [VOLTAGE] [0] [ON] [EXECUTE]

To establish a 3-phase current of 5 amperes with a MTA of 80° and 120° separation, the following commands are necessary

[CURRENT] [0] [AC] [5] [CURRENT] [1] [PHASE] [8][0]

[CURRENT] [2] [PHASE] [2][0][0] [CURRENT] [3]

[PHASE] [3][2][0] [CURRENT] [0] [ON] [EXECUTE]

Now to simultaneously ramp the 3-phase current, use the commands;

[CURRENT] [0] [AC] ▵ or ▿

And with the appropriate ramp arrow key (up or down), the current amplitude will be ramped simultaneously.

1.7.2 The following is an example of a two stage fault executed manually with a PULSAR. The requirements are as follows:

	Prefault		Fault	
	amplitude	phase	amplitude	phase
V1	67	0	10	0
V2	67	120	10	120
V3	67	240	10	240
I1	1	30	5	50
I2	1	150	5	170
I3	1	270	5	290

The following abbreviations will be used too for the PULSAR keypad.

VOLTAGE GENERATOR = v
CURRENT GENERATOR = c
AC AMPLITUDE = a
PHASE = p
EXECUTE = ;

Example
This series of pushbuttons applies the prefault conditions.

v2,p120,v3,p240,v0,a67,on,c1,p30,c2,p150,c3,p270,c0,a1,on;

This series of pushbuttons loads and executes the fault conditions. Only those parameters to be changed had to be entered.

v0,a10,c0,a5,c1,p50,c2,p170,c3,p290;

1.8 Testing Sync-Check, Synchronizing and Auto-Synchronizing Relays

To perform tests on synchronizing type relays requires the use of two voltage output modules.

Pick-up or Closing Angle Tests: To perform Pick-up or Closing Angle tests let one voltage channel be the 0° reference, i.e., V1, and let the second voltage channel provide the variable phase angle adjustment, i.e., V2. Remember the phase angle indicated on V2 will be a **lagging angle** (see SETTING PHASE ANGLE RELATIONSHIPS). If the relay's closing characteristic is 20° leading, set an angle of 340° on voltage channel 2.

To set V1 and V2 to 120 volts each and turn on use the following keystrokes,

VOLTAGE, 1,2, AC, 120, ON, EXECUTE

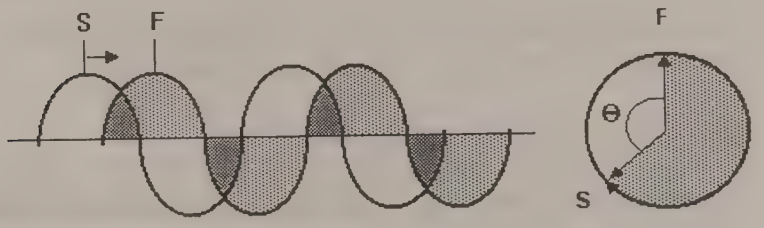
To set V2 to a phase angle of 340° lag (20° lead) use the following keystrokes,

VOLTAGE, 2, PHASE, 340, EXECUTE

To ramp the phase angle of V2 toward 0°, press and hold the appropriate RAMP ▲ arrow until the relay picks up, i.e., 345° (15° leading)

Setting Advance Time: To perform this test let voltage channel 2, V2, provide the slip frequency (generator) and let voltage channel 1, V1, provide the fixed voltage/frequency source (bus). Connect the relay's closing contacts to Timer Start Terminal 1 (top pair of terminals), so that when the relay contacts close (at the advance angle) it will start the timer. Set V1 to the appropriate voltage output and turn on. For example: **VOLTAGE, 1, AC, 120, ON, EXECUTE**. Set V2 to an appropriate output

voltage and slip frequency, but do not turn on yet. For example: **VOLTAGE, 2, AC, 120, FREQ., 60.100, EXECUTE**. V2 DEGREES display should have dashed lines (the dashes will reset to zero's when the test is executed). Set V1 and V2 to turn on and the Timer to Stop On Synchronization by pressing, **VOLTAGE, 1, 2, Shift, TSOS, ON, EXECUTE**. V2 will turn on in phase with V1, but will slip out of phase at the selected slip frequency. At the advance angle the relay contacts will close, thus starting the timer, when the two voltages slip into phase the Timer will stop. The time indicated will be the advance time setting of the relay. See the following figure for a graphic representation.



S - SLIP FREQUENCY F - FIXED FREQUENCY SYNCHROSCOPE

As "S" approaches "F", at some point (the advance angle) the relay will send a close signal, which will start the Timer. When "S" and "F" are in synchronous, the Timer will stop. The time indicated on the timer display is the advance time of the relay based on the preset slip frequency.

1.9 Testing Frequency Relays

The following test guidelines apply generally to all frequency sensitive relays, such as over/under frequency and volts per Hertz.

NOTE: Only one voltage output module is required.

A. Pick-Up Test

To set up the PULSAR for frequency pick-up test, use the following procedure:

1. Switch the POWER ON/OFF Switch ON.

2. Select one of the voltage modules to provide the desired frequency output.

3. Connect a pair of voltage output leads from the selected voltage channel to the relay. Connect a pair of leads from the Timer module, monitor terminals (Terminal 3) to the relay's trip contacts.

4. Set the desired output voltage and initiate the output. For example, use the following keystrokes, **VOLTAGE, 1, AC, 120, SHIFT, SZ, ON, EXECUTE**. The output "**ON**" light should be displayed on the voltage amplifier front panel.

   NOTE: The SZ (Self Zero) function was selected. This is important. All changes made to the frequency will take place at the positive zero crossing. Most solid-state and microprocessor-based frequency relays determine frequency and timing based on zero crossings.

5. Increase or decrease the output frequency to the appropriate value by selecting FREQ then press the respective ▵or ▿ RAMP buttons until the relay indicates pick-up.

B. Timing Test

Over/Under Frequency Relays can be dynamically tested using one voltage channel of the PULSAR test set along with the timer module. This procedure applies a "*normal*" voltage and frequency to the relay under test and then automatically adjusts the test voltage to a "*fault*" frequency, either higher for testing over frequency relays, or to a lower frequency for testing under frequency relays. It should also be noted that the voltage amplitude can be changed with the frequency for more realistic dynamic testing. The timer is automatically started with "*fault*" frequency applied to the relay under test. To set up the PULSAR for frequency timing test, use the same set-up as for the pick-up test (except move the Monitor leads from Timer Terminal 3 to Timer Stop Terminal 2) and the following procedure:

1. Set the "normal" voltage on the relay. For example, **VOLTAGE, 1, AC, 120, SHIFT, SZ, ON, EXECUTE** (see NOTE above relative to the SZ mode).

2. With the relay energized to normal condition, set the desired "fault" frequency / voltage and Timer Start (relay trip circuit should be connected to the Timer Stop terminals, Terminal 2). If you want to de-energize the voltage to the relay when it trips, use the Auto-Off feature. For example, setting a "fault" frequency of 58.880 Hz with Auto-Off the commands would be: **FREQ, 58.88, TIMER START, Shift, A-OFF, ON, EXECUTE**. The 58.880 Hz. will be applied, the Timer will Start, the relay trips, stops the Timer and turns the outputs OFF. The Time indicated on the display is the operating time of the relay.

3. To do a re-test, reset the frequency to the "normal" frequency using the following keystrokes, **FREQ, 60, SHIFT, RST .PH., ON, EXECUTE**. Repeat step 2.

NOTE: The RST.PH. function was selected to restore phase angle relationship. This is required if conducting a dynamic frequency timing test using three-phase voltage and/or current.

APPLICATION NOTE: To conduct a more dynamic test including a change in voltage amplitude (i.e. change frequency to 50 Hz and amplitude to 100 volts) see the following. In step 2 "setting a fault" use the following keystrokes, **AC, 100, FREQ, 50, TIMER START, Shift, A-OFF, ON, EXECUTE**. The voltage will change to 100 volts at 50 Hz and the Timer will start all at the same time.

4. Once all tests are completed, restore SYNC to Phase Reference using the following key strokes, **SHIFT, PR, EXECUTE**.

2.0 Testing DC Target And Seal-In

The following test guidelines apply generally to all DC target and seal-in elements. At least one current channel is required to do the target and seal-in test. If two current channels are available, use one current to provide AC current to close the trip contacts and use the other to provide the DC current. The following procedure is based on having two currents available.

NOTE: If two currents are not available, block the trip contacts closed prior to conducting test. Remember to remove the block after the test is completed.

1. Switch the POWER ON/OFF Switch ON.

2. Select one of the current output channels to provide the AC current (for this example current channel 1). Connect a pair of leads to the appropriate relay terminals to energize the relay trip element.

3. Connect current channel 2 to the appropriate relay terminals to energize the DC target and seal-in elements.

4. Set the desired AC test current to approximately 150 % of the relay tap value and turn on. For example, if the relay tap setting is 4 Amperes, use the following keystrokes, **CURRENT, 1, AC, 6, ON, EXECUTE**.

5. When the relay trip element contacts close, energize the relay target coil with DC using the following keystrokes, **CURRENT, 2, DC, ON, EXECUTE**. Ramp up the DC current using the appropriate RAMP Arrow key until the target drops and the seal-in coil picks-up, read and record the DC amperes.

6. Turn off current channel **1** using the following keystrokes, **CURRENT, 1, OFF, EXECUTE**. Note that the seal-in element should still be picked-up. Turn channel 1 back on by pressing **ON, EXECUTE**.

7. Select current channel 2 using the following keystrokes, **CURRENT, 2, DC, EXECUTE**. Slowly reduce the DC current, by pressing the appropriate RAMP arrow key down until the target element drops out, read and record drop out current.

8. Turn current channels 1 and 2 off using the following keystrokes, **CURRENT, 1, 2, OFF, EXECUTE**. Turn test set off.

D. SERVICE DATA

1.1 Servicing

The PULSAR utilizes surface mount technology (SMT) and components which require little or no service except for routine cleaning, tightening of connections, etc. The PULSAR should be serviced in a clean atmosphere away from energized electrical circuits. The following maintenance is recommended:

1. Examine the unit every six months for:
   a. Dust and other particulate matter collecting on the fins of the heat sinks.
   b. Moisture condensation inside the lens covers of the display(s).
   c. Corrosion on the exposed metal surfaces.

2. Remove dust with dry, low pressure, compressed air. Either remove the module from the chassis or simply apply air through the louvers on the front of the module forcing the dust out the rear.

3. Remove moisture as much as possible by putting the test set in a warm, dry environment.

4. As corrosion may take many forms, no specific recommendations can be made for its removal.

1.2 Service and Repair Order Instructions

If factory service is required or desired, contact the factory for return instructions.

A Repair Authorization (RA) number will be assigned for proper handling of the unit when it arrives at the factory.

If desired, a letter with the RA number and instructions can be provided.

Provide the factory with model number, serial number, nature of the problem or service desired, return address, your name, and where you can be reached should the factory need to contact you.

If desired, you may also provide a purchase order number, cost limit, billing, and return shipping instructions.

National Institute of Standards and Technology (NIST) traceable calibration and certification of two types is available, if desired, at additional cost.

Class One: A certificate is provided verifying the traceability and calibration of the equipment.

Class N: That which is required for nuclear power plants. A certificate of traceability and calibration along with "as found" and "as left" data are provided.

If an estimate is requested, provide the name and contact information of the person with approval/disapproval authority.

Pack the equipment appropriately to prevent damage during shipment. If a reusable crate or container is used, the unit will be returned in it if it is in suitable condition.

Put the RA number on the address label of the shipping container for proper identification and faster handling.

NOTE: Ship the equipment **without** instruction manuals or nonessential items such as test leads, etc. These items are not needed to conduct repairs.

1.3 Preparation for Reshipment

Save the shipping container for future use. The shipping container your unit came in is designed to withstand the normal bumps and shocks of shipping via common commercial carrier. For example, you may wish to reship your unit to AVO Multi-Amp for annual calibration certification.

E. WARRANTY STATEMENT

AVO Multi-Amp Corporation warrants to the original purchaser that the product is free of defects in material and workmanship for a period of one (1) year from date of shipment. This warranty is limited and shall not apply to equipment which has damage, or cause of defect, due to accident, negligence, improper operation, faulty installation by the purchaser, or improper service or repair by any person, company or corporation not authorized by AVO Multi-Amp Corporation.

AVO Multi-Amp Corporation will, at its' option, either repair or replace those parts and/or materials that it deems to be defective. Any costs incurred by the purchaser for the repair or replacement of such parts and/or materials shall be the sole responsibility of the original purchaser.

THE ABOVE WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED ON THE PART OF THE MULTI-AMP CORPORATION, AND IN NO EVENT SHALL THE AVO MULTI-AMP CORPORATION BE LIABLE FOR THE CONSEQUENTIAL DAMAGES DUE TO THE BREACH THEREOF.

F. REPAIR DATA

It is not always necessary to return the complete PULSAR to the factory for repair. To save turn-around time and reduce costs, PULSAR was designed as a modular unit. In most cases, if any one module should experience a problem it should not cause the test system to be down. Basic troubleshooting information has been provided to guide the technician to the possible source of a problem.

Most of the problems experienced with the PULSAR can be corrected with a replacement module. Since PULSAR uses Surface Mount Technology, most repairs of the individual modules are beyond the scope of the basic troubleshooting guide, and should be referred to the Service Department at AVO Multi-Amp or handled through the AVO Multi-Amp Representative.

If the unit is still within the original warranty period, or limited warranty period following factory servicing, **the factory must be contacted before attempting any repairs or the warranty will be void.**

1.1 Basic Troubleshooting

The troubleshooting information relies on the technician to have a through understanding of the operation of the unit. If the technician is unfamiliar with the unit, he or she should not attempt to repair. The technician should contact the factory before attempting repairs. Provide the AVO Multi-Amp part number for the part or assembly in question and the serial number of the PULSAR when making inquiries.

WARNING

It is necessary to energize the PULSAR to properly troubleshoot some of the modules. The technician must take all applicable safety precautions for working on energized circuits.

NOTES

Before suspecting a failure in the PULSAR, review the Description of Controls and Theory of Operation sections to ensure that the problem is not a result of operating error.

Preliminary testing of the PULSAR within its specified limits can help determine if a malfunction actually exists, identify the type of malfunction and define the general area of the failure.

Common causes of malfunctions, other than improper operation, are incorrect power input (voltage above or below specified limits), incorrect test signal voltages applied to the Timer Module Monitor/Start/Stop gates (outside of the specified AC/DC Applied/Removed limits), and contact or circuit resistance too great for the Dry Contact gates to operate properly on the Monitor/Start/Stop gates.

NOTE: Proper ESD procedures should be followed when handling any Pulsar module.

1.2 Power Input

Input voltage affects the whole unit and may or may not cause permanent damage if voltage is incorrect. These problems can often be corrected by simply using a better source of input power. The rated voltage limits is auto-selectable from 95 to 265 volts, 47 to 63 Hz.

Some symptoms are as follows:

1. Low voltage: Erratic operation, no output, fuse operation.

2. High voltage: Fuse operation, power supply failure in Input Power Control Module.

1.3 Input Power and Control Module

Basic troubleshooting of the input power and front panel controls are as follows.

1. No power:
   Check power source and line cord.

2. Erratic manual Control
   A. Individual Output Module or Timer Module is not properly set into the back plane connector, thus cannot receive proper commands.

      CAUTION: Turn off main power and unplug line cord before attempting to reseat any module.

      Press firmly on front of each suspect module to see if it reseats, check tightness of back panel knurl knobs on each module.
   B. Input Power Control Module is not properly set into the back plane connector. Press firmly on front of the module to see if it reseats, check tightness of back panel knurl knob.
   C. If only one button appears to be not operating properly, then it is likely that the sealed switch is bad. Contact the Service and Repair Department for return instructions.

3. Removal of Input Power and Control Module:
   To remove the module from the chassis,
   A. Disconnect the power cord from the unit.
   B. Carefully remove the screws located in the front-bottom of the module.
   C. Carefully remove the screw, located in the back, which secures the chassis safety ground (earth) wire (green wire) to the chassis. This screw is only accessible through the hole provided, next to chassis ground (earth) point. Use a screw-holding screw driver to remove, else the screw could fall behind the back panel cover.
   D. Remove the knurl knob retaining screw located on the back panel between the Serial Interface and the Input Power Connector.
   E. Hold the front of the Module with one hand, and gently, yet firmly, press forward with the other hand on the back fan outlet port. Slide the module forward until you can grasp it with both hands from the front. Carefully remove the module from the chassis.

      If all checks good, then power supply failure is probable. Contact factory for return instructions.

1.4 Timer, Monitor and Battery Simulator Module

If all the items external of the Timer assembly are in proper order, then the problem exists within the Timer assembly itself.

It is usually recommended that the complete Timer Module assembly be returned for factory repair if found to be defective. Then any improvements that have been made in the assembly can be incorporated into it during repair and servicing. Some basic troubleshooting can pinpoint problems to the approximate cause.

Basic troubleshooting is as follows:

1. No Timer display when the PULSAR is energized:
   Timer Module power supply failure, defective display IC's, defective components on or back panel connections.

   CAUTION: Turn off main power and unplug line cord before attempting to reseat any module.

   Check Input Power Control and Timer Modules, make sure they are properly seated into the back plane connector. Press firmly on front of the module to see if it reseats, check tightness of back panel knurl knob. If power supply failure is suspect, contact factory or representative for instructions.

2. Weak or defective display:
   Poor supply voltage, defective display(s), defective components on display board. See step 1 above for corrective action.

3. Problems with SEC/CYCLES selection:
   Defective selector switch(es) on the Input Control Module, defective circuit or defective IC's on timer board. More than likely, problem is selector switch on Control Module (see corrective action under Input Power and Control Module, Erratic Manual Operation). If timer board is suspect, contact factory or representative for instructions.

4. Counting errors:
   AC applied or removed Start/Stop signals can create, what appears to be poor repeatability, an inaccuracy or a malfunction in the Timer. The lower the voltage level, the more serious the "error" will be. What appears to be an error, however, is actually a variation in the point on the sine wave at which the voltage is great enough to cause the gate circuit to operate. If the circuit used for the timing test has a low AC voltage and the point at which the contact in the test circuit opens or closes, is at or close to zero

on the sine wave, the period of time before the voltage level will be high enough to trigger the gate circuit can be as much as 4 milliseconds. The total timing variation can be as much as 8 milliseconds. The shorter the duration of the timing test, the more significant the variation becomes. Therefore, if small timing variations would present a problem, it is recommended that an AC voltage of 115 volts or above or a DC voltage be used for voltage applied/removed test selections.

When the PULSAR Timer calibration is being tested, the AC voltage variable is often overlooked. This is particularly true when the Timer is compared to a counter and the two are triggered simultaneously with an electronic switch. For best results, a DC voltage should be used to eliminate the variable. If testing the AC voltage Start/Stop characteristics is desired, then the Start/Stop signal must be triggered at the same point on the sine wave to assure that the gate signal will be repeatable. Ideally, the signal should be at a point near peak in the positive direction. In addition, the specified rms AC voltage values for the various Start/Stop control selections must be adhered to.

Another source of apparent "error" can be the programmable de-bounce feature. If using electro-mechanical contacts for starting and stopping the Timer, and if those contacts have a tendency to bounce, there could be a difference between an external standard timer and the PULSAR Timer, depending on the programmed de-bounce period. To determine the programmed value, use a computer to perform a Timer Query (see Command Set for instructions).

If a timing error or variation persists after all the suspected causes of error have been eliminated, then it is fairly certain the Timer is malfunctioning. Contact factory for return instructions.

5. Removal of Timer Module

To remove the module from the chassis,

A. Disconnect the power cord from the unit.
B. Carefully remove the screws located in the front-bottom of the module.
C. Remove the knurl knob retaining screw located on the back panel.
D. Hold the front the Module with one hand and gently, yet firmly, press forward with the other hand on the back fan outlet port. Slide the module forward until you can grasp it with both hands from the front. Carefully remove the module from the chassis.

1.5 Voltage Amplifier Module

It is usually recommended that the complete Voltage Amplifier Module assembly be returned for factory repair if found to be defective. Then any improvements that have been made in the assembly can be incorporated into it during repair and servicing. Due to the extensive use of Surface Mount Technology in the amplifier module, there is very little that can be repaired without special tools and training. Some basic troubleshooting can pinpoint problems to the approximate cause.

Basic troubleshooting is as follows:

1. No Voltage Module display when the PULSAR is energized:
   Voltage Amplifier Module power supply failure, defective display IC's, defective components on or back panel connections.
   CAUTION: Turn off main power and unplug line cord before attempting to reseat any module.
   Check Input Power Control and Voltage Amplifier Modules, make sure they are properly seated into the back plane connector. Press firmly on front of the module to see if it reseats, check tightness of back panel knurl knob. If power supply failure is suspect, contact factory or representative for instructions.

2. Weak or defective display:
   Poor supply voltage, defective display(s), defective components on display board. See step 1 above for corrective action.

3. DC voltage output with amplifier turned off:
   It is normal to have a few millivolts of dc voltage with the output switched off, since the amplifier is dc coupled. However, if the power supply starts to fail, the operator may measure 10's of volts dc across the output binding post. This is an indication that the power supply has a problem and needs to be replaced. Contact factory for return instructions.

4. Removal of Voltage Amplifier Module
   To remove the module from the chassis,
   A. Disconnect the power cord from the unit.
   B. Carefully remove the screws located in the front-bottom of the module.
   C. Remove the knurl knob retaining screw located on the back panel.
   D. Hold the front the Module with one hand and gently, yet firmly, press forward with the other hand on the back fan outlet port. Slide the module forward until you can grasp it with both hands from the front. Carefully remove the module from the chassis.

1.6 Current Amplifier Module

It is usually recomr ended that the complete Current Amplifier Module assembly be returned for factory repair if found to be defective. Then any improvements that have been made in the assembly can be incorporated into it during repair and servicing. Due to the extensive use of Surface Mount Technology in the amplifier module, there is very little that can be repaired without special tools and training. Some basic troubleshooting can pinpoint problems to the approximate cause.

Basic troubleshooting is as follows:

NOTE:

1. No Current Module display when the PULSAR is energized:
   Current Amplifier Module power supply failure, defective display IC's, defective components on or back panel connections.
   CAUTION: Turn off main power and unplug line cord before attempting to reseat any module. Check Input Power Control and Current Amplifier Modules, make sure they are properly seated into the back plane connector. Press firmly on front of the module to see if it reseats, check tightness of back panel knurl knob. If power supply failure is suspect, contact factory or representative for instructions.

2. Weak or defective display:
   Poor supply voltage, defective display(s), defective components on display board. See step 1 above for corrective action.

3. Removal of Current Amplifier Module
   To remove the module from the chassis,

   A. Disconnect the power cord from the unit.
   B. Carefully remove the screws located in the front-bottom of the module.
   C. Remove the knurl knob retaining screw located on the back panel.
   D. Hold the front the Module with one hand and gently, yet firmly, press forward with the other hand on the back fan outlet port. Slide the module forward until you can grasp it with both hands from the front. Carefully remove the module from the chassis.

II. Testing Procedures

Testing of Westinghouse Type AR Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 94
Function: Auxiliary

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the AR's protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — I.L. 41-759

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The AR relay is a high-speed auxiliary relay used in breaker-failure protection schemes to initiate a breaker-lockout device to restrict energizing of a circuit breaker once a fault has occurred.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs OFF before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS					
ASSIGN	±	N	TEST	∠	Hz
V_A	8	9	120	0°	60.0
MON	10	1			

MINIMUM PICKUP

1. Relay connections are applicable to test either ac or dc voltage relays.
2. Apply rated voltage to relay; **VOLTAGE, 1, AC, 120, ON, EXECUTE**.
3. Using the Ramp Arrow keys, ramp voltage up or down to find minimum pickup value.
4. To turn VOLTAGE 1 Off; **OFF, EXECUTE**.
5. Voltage pickup should be ±10% of tap or relay voltage rating.

TIMING

1. Move monitor leads to timer stop gate on PULSAR.
2. Apply multiples of fault level voltages to AR relay; **VOLTAGE, 1, AC, 80, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE**.
3. Subsequent sequences are;
   AC, 90, ON, TIMER START, EXECUTE;
   AC, 100, ON, TIMER START, EXECUTE;
   AC, 110, ON, TIMER START, EXECUTE;
   AC, 120, ON, TIMER START, EXECUTE;
   Record each individual value.
4. De-initiate auto off function; **SHIFT, A-OFF, OFF, EXECUTE**.

Testing of General Electric Type BDD 15 & 16 Relays

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 87
Function: Transformer Differential

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the BDD15B protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — GEH-2057F

Test Equipment — PULSAR Operating Manual
Instructional Material

Description of Relay

BDD relays are differential relays designed specifically for transformer protection. The BDD relays are provided with the features of percentage and harmonic restraint and use a sensitive polarized unit as the operation element. Percentage restraint permits accurate discrimination between internal and external faults at high fault current, while harmonic restraint enables the BDD to distinguish, by the difference in waveform between the differential current caused by an internal fault and that of transformer magnetizing inrush.

The BDD relay is a single-phase unit and the BDD15B relay is designed to be used for the protection of a two winding transformer and has two through current restraint circuits and one differential current circuit.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table. The test values are based upon a 5A tap and 25% slope relay setting.

The dc auxiliary is supplied either using the station dc battery supply or the PULSAR Battery Simulator. The dc terminals to connect are 1 (+) and 7 (-). These settings assume usage of the 125 V version.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	1.2	0°	60.0
I_B	4	5	I_B	1.2	0°	60.0
MON	1	2				

MINIMUM PICKUP

1. Set PULSAR current channels equal to (tap * 0.3) value; **CURRENT, 1, 2, AC, 1.2, EXECUTE**.
2. Turn current (I_A) ON; **CURRENT, 1, AC, ON, EXECUTE**. Using RAMP Arrow keys, ramp current channel up or down to find minimum pickup. Turn I_A off; **CURRENT, 1, OFF, EXECUTE**. Repeat test for current (I_B), all commands for I_B are CURRENT 2.
3. Minimum pickup should be within ±10% of (tap * 0.3) value. Refer to relay instruction manual for adjustment to minimum pickup resistor.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	4	I_A	25	0°	60.0
MON	1	2				

THROUGH CURRENT RESTRAINT

1. Set PULSAR current channel (I_A) equal to 25 amperes; **CURRENT, 1, AC, 25, EXECUTE**.
2. Turn current (I_A) ON; **CURRENT, 1, ON, EXECUTE**; BDD15B relay should be in restraint, (relay's main trip contacts remain open rather than close).
3. Turn current OFF; **OFF, EXECUTE**. Disconnect relay and set up for Harmonic restraint test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	5	I_B	1	0°	120.0
MON	1	2				

HARMONIC RESTRAINT using pure 2nd Harmonic Current

1. Set I_A and I_B on PULSAR to above parameters; **CURRENT, 2, AC, 1, FREQ, 120, SHIFT, RST.PH, CURRENT 1, AC, 4, EXECUTE**.
2. Initiate PULSAR; **CURRENT, 2, ON, CURRENT 1, AC, ON, EXECUTE**. Using the RAMP Arrow keys ramp I_A up to find pickup of harmonic restraint trip contact. Record value.
3. De-initiate PULSAR; **CURRENT, 1, 2, OFF, EXECUTE**.
5. Calculate percent harmonic with the formula as referred to under Current Sources-Harmonic Restraint Test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	5	I_B	8.89	0°	60.0
MON	1	2				

HARMONIC RESTRAINT using H_WAVE (Diode Test Method)

1. Set I_A to above parameters; **CURRENT, 1, AC, 4, EXECUTE**.
2. Set I_B to 8.89A, H_WAVE, to establish 4A I_{dc} (as required for diode test method), refer to section Current Sources-Harmonic Restraint Test; **CURRENT, 2, AC, 8.89, SHIFT, H_WAVE, EXECUTE.**
3. Initiate I_A and I_B; **CURRENT, 2, ON, CURRENT, 1, AC, ON, EXECUTE**.
4. Using the RAMP Arrow keys, ramp I_A up to find pickup of harmonic restraint trip contact. Record value.
5. De-initiate PULSAR; **CURRENT, 1, 2, OFF, EXECUTE**.
6. Restore to sine wave output; **CURRENT, 0, SHIFT, SINE, EXECUTE**.
7. Refer to the manufacturers instruction literature for the appropriate % Harmonic Curve.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	4	I_B	20	0°	60.0
MON	1	2				

SLOPE TEST

1. Set I_A equal to 4 amperes and I_B equal to 20 amperes; **CURRENT, 1, AC 4, CURRENT, 2, AC, 20, EXECUTE**.
2. Turn both I_A and I_B ON; **CURRENT, 2, ON, CURRENT, 1, AC, ON, EXECUTE**. Using the RAMP Arrow keys ramp I_A up until main trip

contacts pickup. Record pickup value, turn I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE**.

3. Using the formula; %Slope = $(I_A/I_B)*100$, calculate the actual BDD15B slope characteristics. Refer to GEH-2057F for tolerances.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	20	0°	60.0
I_B	6	5	I_B	20	0°	60.0
MON	1	2				

INSTANTANEOUS TEST

1. Set I_A and I_B equal to (8 * 5A tap); **CURRENT, 1, 2, AC, 20, EXECUTE**.
2. Turn both I_A and I_B ON; **CURRENT, 1, 2, ON, EXECUTE**. Pulse current to instantaneous unit by turning the current on and off to the BDD relay using the following commands. **ON, EXECUTE; OFF, EXECUTE**.
3. If contacts pickup, reduce current values by 1.0 amp; **CURRENT, 1, 2, AC, 19.5, ON, EXECUTE, OFF EXECUTE**; until main trip contacts pickup. Record pickup value
4. Turn I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE**.

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 87
Function: Transformer Differential

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the BDD16B protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — GEH-2057F

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

BDD relays are differential relays designed specifically for transformer protection. The BDD relays are provided with the features of percentage and harmonic restraint and use a sensitive polarized unit as the operation element. Percentage restraint permits accurate discrimination between internal and external faults at high fault current, while harmonic restraint enables the BDD to distinguish, by the difference in waveform between the differential current caused by an internal fault and that of transformer magnetizing inrush.

The BDD relay is a single-phase unit and the BDD16B relay is designed to be used for the protection of a three winding transformer and has three through current restraint circuits and one differential current circuit.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table. The test values are based upon a 5A tap and 25% slope relay setting.

The dc auxiliary is supplied either using the station dc battery supply or the PULSAR Battery Simulator. The dc terminals to connect are 1 (+) and 10 (-). These settings assume usage of the 125 V version.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	1.2	0°	60.0
I_B	4	5	I_B	1.2	0°	60.0
I_C	3	5	I_C	1.2	0°	60.0
MON	1	2				

MINIMUM PICKUP

1. Set PULSAR current channels equal to (tap * 0.3) value; **CURRENT, 0, AC, 1.2, EXECUTE**.
2. Turn current (I_A) ON; **CURRENT, 1, AC, ON, EXECUTE**. Using RAMP Arrow keys, ramp current channel up or down to find minimum pickup. Turn I_A OFF; **CURRENT, 1, OFF, EXECUTE**. Repeat test for current (I_B and I_C), all commands for I_B are CURRENT, 2 and I_C are CURRENT, 3.
3. Minimum pickup should be within ±10% of (tap * 0.3) value. Refer to relay instruction manual for adjustment to minimum pickup resistor.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	3	I_A	25	0°	60.0
I_B	6	4	I_B	25	0°	60.0
MON	1	2				

THROUGH CURRENT RESTRAINT

1. Set PULSAR current channel (I_A) equal to 25 amperes; **CURRENT, 1, AC, 25, EXECUTE**.
2. Turn current (I_A) ON; **CURRENT, 1, ON, EXECUTE**. BDD16B relay should be in restraint, (relay's main trip contacts remain open rather than close).
3. Turn current OFF; **OFF, EXECUTE**.
4. Repeat the test for I_B; **CURRENT, 2, AC, 25, ON, EXECUTE**. Turn current OFF; **OFF, EXECUTE**. Disconnect relay and set up for Harmonic Restraint test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	5	I_B	1	0°	120.0
MON	1	2				

HARMONIC RESTRAINT using pure 2nd Harmonic Current

1. Set I_A and I_B on PULSAR to above parameters; **CURRENT, 2, AC, 1, FREQ, 120, SHIFT, RST.PH, CURRENT, 1, AC, 4, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 2, ON, CURRENT, 1, AC, ON, EXECUTE**. Using the RAMP Arrow keys ramp I_A up to find pickup of harmonic restraint trip contact. Record value.
3. De-initiate PULSAR; CURRENT, 1, 2, OFF, EXECUTE.

4. Calculate percent harmonic with the formula as referred to under Current Sources-Harmonic Restraint Test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	5	I_B	8.89	0°	60.0
MON	1	2				

HARMONIC RESTRAINT using H_WAVE (Diode Test Method)

1. Set I_A to above parameters; **CURRENT, 1, AC, 4, EXECUTE**.
2. Set I_B to 8.89A, H_WAVE, to establish 4A I_{dc} (as required for diode test method), refer to section Current Sources-Harmonic Restraint Test; **CURRENT, 2, AC, 8.89, SHIFT, H_WAVE, EXECUTE**.
3. Initiate I_A and I_B; **CURRENT, 2, ON, CURRENT, 1, AC, ON, EXECUTE**.
4. Using the RAMP Arrow keys, ramp I_A up to find pickup of harmonic restraint trip contact. Record value.
5. De-initiate PULSAR; **CURRENT, 1, 2, OFF, EXECUTE**.
6. Restore sine wave output; **CURRENT, 0, SHIFT, SINE, EXECUTE**.
7. Refer to the manufacturers instruction literature for the appropriate % Harmonic Curve.5

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	4	0°	60.0
I_B	6	4	I_B	20	0°	60.0
I_C	4	3	I_C	20	0°	60.0
MON	1	2				

SLOPE TEST

1. Set I_A equal to 4 amperes and I_B equal to 20 amperes; **CURRENT, 1, AC 4, CURRENT, 2, AC, 20, EXECUTE**.
2. Turn both I_A and I_B ON; **CURRENT, 2, ON, CURRENT, 1, AC, ON, EXECUTE**. Using the RAMP Arrow keys ramp I_A up until main trip contacts pickup. Record pickup value, turn I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE**.
3. Using the formula; % Slope = $(I_A/I_B)*100$, calculate the actual BDD16B slope characteristics. Refer to GEH-2057F for tolerances.
4. Repeat the test for I_A and I_C.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	6	5	I_A	20.0	0°	60.0
I_B	6	5	I_B	20.0	0°	60.0
MON	1	2				

INSTANTANEOUS TEST

1. Set I_A and I_B equal to (8 * 5A tap); **CURRENT, 1, 2, AC, 20, EXECUTE**.
2. Turn both I_A and I_B ON; **CURRENT, 1, 2, ON, EXECUTE**. Pulse current to instantaneous unit by turning the current on and off to the BDD relay using the following commands. **ON, EXECUTE; OFF, EXECUTE**.
3. If contacts pickup, reduce current values by 1.0 amp; **CURRENT, 1, 2, AC, 19.5, ON, EXECUTE, OFF EXECUTE**; until main trip contacts pickup. Record pickup value
4. Turn I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE**.

Testing of Basler Type BE1-81 O/U Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 81
Function: Frequency Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the BE1-81 O/U protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-501.2F
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The BE1-81 O/U is a single phase solid-state relay used in protection schemes against the effects of overfrequency or underfrequency.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The BE1-81 O/U Digital Frequency Relay is a solid-state,digital electronic protective device that monitors the frequency of a single-phase of ac voltage to provide accurate frequency protection for 50 Hz or 60 Hz distribution systems and generators.

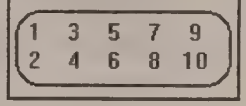
Test Connections:

125 VDC: 3 AND 4

Frequency sensing: 6 and 7

Contacts: Set point 1, 1 and 10
Set point 2, 8 and 9

BASLER
BE1-81 O/U
(Front view of the relay with the test plug inserted)



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O	O O	O O
	AMPS		AMPS		AMPS
	O O		O O		O O

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

The BE1-81 O//U relay is used as an overfrequency and underfrequency characteristics.

Refer to BE1-81 O/U instruction manual for relay settings for OPERATIONAL TEST.

Use Battery Simulator for dc power supply 4(+) and 3(-).

Assign voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	6	V_A	80	0°	60.0
MON	10	1				

OVERFREQUENCY TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 80, ON, SHIFT, SZ, FREQ, EXECUTE.** NOTE: The 80 Volts applied should just exceed the UNDERVOLTAGE INHIBIT sensing circuit, unless it is set higher.
2. Using Ramp Arrow keys ramp V_A frequency up until main trip contacts pickup, 70.01 Hz ±0.005 Hz.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

UNDERFREQUENCY TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 80, ON, SHIFT, SZ, FREQ, 50, EXECUTE.** NOTE: The 80 Volts applied should just exceed the UNDERVOLTAGE INHIBIT sensing circuit, unless it is set higher.
2. Using Ramp Arrow keys ramp V_A frequency down until main trip contacts pickup, 40.00 Hz ±0.005 Hz.
3. Record the minimum pickup value.

4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

FREQUENCY SELECTOR TEST

1. Set V_A equal to frequency test parameters and initiate; **VOLTAGE, 1, AC, 80, ON, SHIFT, SZ, FREQ, 50, EXECUTE.** NOTE: The 80 Volts applied should just exceed the UNDERVOLTAGE INHIBIT sensing circuit, unless it is set higher.
2. Using Ramp Arrow keys ramp V_A frequency up until main trip contacts pickup, 51.11 Hz ±0.005 Hz.
3. Record the minimum pickup value.
4. Repeat steps 1 and 2 for BE1-81 settings of 52.22 Hz, 54.44 Hz, and 58.88 Hz.
5. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage and frequency; **VOLTAGE, 1, AC, 115, FREQ, 60, ON, SHIFT, RST. PH, SZ, EXECUTE.**
2. Move monitor circuit to timer stop gate. (Terminal 2).
3. Set V_A equal to fault voltage and fault frequency 53 Hz; **VOLTAGE, 1, AC, 80, FREQ, 53, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. When the relay trips, it will turn off the output and stop the Timer. Record the pickup value. Repeat testing sequence for any additional fault values. If timing type E1 (definite time delay), use formula:

$$Time_{delay} = \frac{11_{cycles}}{input_{frequency}}$$

If timing type D1 (inverse time delay), use formula:

$$Time_{delay} = Plot_{point} + \frac{3_{cycles}}{Input_{frequency}}$$

Depending on the timing type formula used, the PULSAR timer should equal the Time delay calculated for the BE1-81 .

5. To reset PULSAR to original default settings press RESET button on Input Power and Control Module.

Testing of General Electric Type CEB Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 21
Function: Distance Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CEB12B protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature GEK-26240

Test Equipment PULSAR Operating Manual
Instructional Material

Description of Relay

The CEB12 and CEB51 relays are single-phase, single zone, mho distance relay with provisions for offsetting the characteristic. The relays are designed primarily for use where one zone of back-up protection is required. Probably the most common application of the CEB relays is in generator back-up protection schemes where the relays are used to protect the generator from faults on the adjacent system which are not cleared by the first line relays.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

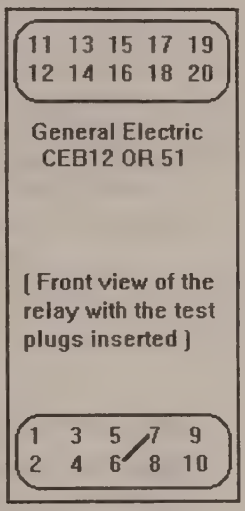
Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

This relay is an out of step blocking relay. The relay will be tested with a single potential and a current source.

Test Connections:

Potentials: 17 and 18, polarity on 17.
Currents: Jumper 6-7, polarity on 5 and common on 8.
Contacts: 1 to 20, or 20 to the midpoint of the contact ring.



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

Jumper relay terminals 6 to 7.

All test values are based upon a 60° maximum torque angle, 5Ω Reach, and the following formula:

$$Z = \frac{V}{2xI}$$

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	17	18	V_A	55	0°	60.0
I_A	5	8	I_A	5	60°	60.0
MON	1	20				
* = Value depends on offset tap						

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

REACH TEST

1. Connect the Monitor circuit to the appropriate relay contacts.
2. Set I_A to 5A and 60°, set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60 , VOLTAGE, 1, AC, 55, EXECUTE.**
3. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.** Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value,refer to the CEB51 I.L. for any adjustment.
5. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

MAXIMUM TORQUE ANGLE

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (± 30°) and repeat the procedure used to determine the reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90°,(± 30° of MTA), set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 55, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value, refer to the CEB51 I.L. for any adjustment.
4. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.
5. Repeat the same test steps for the 30° angle (± 30° of MTA).

OFFSET

1. Set I_A to 5A and 240°, (180°opposite MTA), set V_A equal to (*)+10% above the expected pickup using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 240, VOLTAGE, 1, AC, (*), EXECUTE**.
2. Initiate **PULSAR; CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.**
3. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value and refer to the CEB51 I.L. for any adjustment.
5. Turn V_A and I_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.

Testing of General Electric Type CEY Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 21
Function: Distance Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CEY51A or CEY51B protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — GEK-1265

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The CEY51A and CEY51B relays are three-phase, high speed, single zone, mho distance relay with provisions for offsetting the characteristic. The relays are designed primarily for use where one zone of back-up protection is required. Probably the most common application of the CEY relays is in generator back-up protection schemes where the relays are used to protect the generator from faults on the adjacent system which are not cleared by the first line relays.

PRECAUTIONS

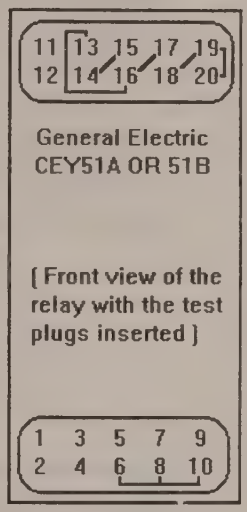
**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

This relay is a three phase,high speed, single zone mho directional relay.
This relay will be tested with a single potential and current source.
Potentials : Jumper 13-16-17,14-15,and 18-19-20. Phase A-B= 15-17, B-C = 17-19 C-A = 19-15.
Currents : Jumper 6-8-10,
Phase A-B= 5-7, B-C= 7-9, C-A = 9-5
contacts :1 & 11, 2 & 11, 3 & 11.


11 13 15 17 19
12 14 16 18 20
General Electric
CEY51A OR 51B
(Front view of the relay with the test plugs inserted)
1 3 5 7 9
2 4 6 8 10

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test·

Assign current and voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

Jumper relay terminals 6 to 8 to 10, 13 to 16 to 17, and 18 to 19 to 20.

All test values are based upon a 60° maximum torque angle, 5 Ω Reach, and the following formula:

$$Z = \frac{V}{2xI}$$

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	15	17	V_A	55	0°	60.0
I_A	5	7	I_A	5	60°	60.0
MON	1	11				
* = Value depends on offset tap						

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

REACH TEST Ø 1-2

1. Connect the Monitor circuit to the appropriate relay contacts.
2. Set I_A to 5A and 60°, set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60 , VOLTAGE, 1, AC, 55, EXECUTE.**
3. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.** Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value,refer to the CEY51 I.L. for any adjustment.
5. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

MAXIMUM TORQUE ANGLE Ø 1-2

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (± 30°) and repeat the procedure used to determine the reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90°,(± 30° of MTA), set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 55, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value. refer to the CEY51 I.L. for any adjustment.
4. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.
5. Repeat the same test steps for the 30° angle (± 30° of MTA).

NOTE: Repeat the same test steps for Ø 2-3, and Ø 3-1. Connections will vary so refer to the CEY51 I.L.

OFFSET

1. Set I_A to 5A and 240°, (180° opposite MTA), set V_A equal to (*)+10% above the expected pickup using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 240, VOLTAGE, 1, AC, (*), EXECUTE**.
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, AC, ON, EXECUTE**.
3. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup and refer to the CEY51 I.L. for any adjustment.
5. Turn V_A and I_A, OFF whenever an adjustment is required or the test is completed; **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.

Testing of Westinghouse Type CF-1 Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 81
Function: Frequency Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CF-1 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-501.2F
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CF-1 is a single phase induction disk relay used in protection schemes against the effects of overfrequency or underfrequency.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The CF-1 is a single phase induction disk relay used in protection schemes against the effects of overfrequency or underfrequency.

Test Connections:

Frequency sensing: 9 and 8,polarity on 9.

Contacts: 1 and 10.

Westinghouse CF-1

(Front view of the relay with the test plug inserted)

2	4	6	8	10	
1	3	5	7	9	

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O→	O O→	O O→
	AMPS		AMPS		AMPS
	O O→		O O→		O O→

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

The CF-1 relay is available as either an overfrequency and underfrequency characteristics. The underfrequency setting is 59 Hz and the overfrequency setting is 62 Hz.

Assign voltage sources as indicated in the preset conditions table.

Underfrequency Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	9	8	V_A	115	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 115, ON, SHIFT, SZ, FREQ, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A frequency down until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage and frequency; **VOLTAGE, 1, AC, 115, FREQ, 60, ON, SHIFT, SZ, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage and fault frequency i. e., 59 Hz and set output to turn off when relay trips and stop timer using the following key strokes; **VOLTAGE, 1, AC, 115, FREQ, 59, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. Record the timing value. Repeat testing sequence for any additional fault voltage and frequency values.
5. To reset PULSAR to original default settings press RESET button on Input Power and Control Module.

Overfrequency Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	9	8	V_A	115	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 115, ON, FREQ, SHIFT, SZ, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A frequency up until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE**.

TIMING TEST

1. Set V_A to normal voltage and frequency; **VOLTAGE, 1, AC, 115, FREQ, ON, SHIFT, SZ, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage and fault frequency i. e., 62 Hz and set output to turn off when relay trips and stop timer using the following keystrokes; **VOLTAGE, 1, AC, 110, FREQ, 62, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. Record the timing pickup value. Repeat testing sequence for any additional fault values.
5. To reset PULSAR to original default settings, press RESET button on Input Power and Control Module.

Testing of General Electric Type CHC11 Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 50
Function: Instantaneous Overcurrent Fault Detector

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CHC11A21 and CHC11B11 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-1253D
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CHC11A and CHC11B relays are a complete three-phase and ground, multi-contact, high speed nondirectional overcurrent relay. The CHC11 consists of an induction cup unit for multi-phase faults and a small hinged armature unit for ground faults. The CHC11B is similar to the CHC11A except that the CHC11B has a dual rated auxiliary telephone relay "A" unit. The CHC11A and CHC11B relays may be applied wherever a high-speed fault detector is required.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

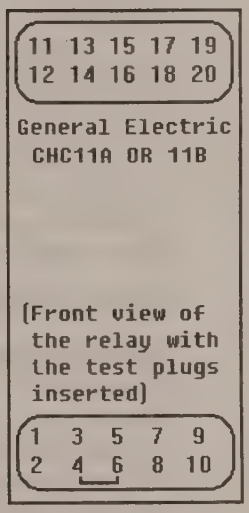
Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The CHC11A and CHC11B relays are a complete three-phase and ground, multi-contact,high speed nondirectional overcurrent relay.

Test Connections:

Jumper 4 to 6, for PFD test only.
Current: PFD, 3 and 5, GFD, 14 and 15.
Contacts: 1 and 12, 2 and 16.


11 13 15 17 19
12 14 16 18 20
General Electric
CHC11A OR 11B
(Front view of the relay with the test plugs inserted)
1 3 5 7 9
2 4 6 8 10

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O	O O	O O
	AMPS		AMPS		AMPS
	O O		O O		O O

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

Jumper relay terminals 4 to 6.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	3	5	I_A	0.5	0°	60.0
I_B	14	15	I_B	0.5	0°	60.0
MON	1	12				
I_A = PFD and I_B = GFD						

PFD - MINIMUM PICKUP

1. Set PULSAR current (I_A) equal to tap value; **CURRENT, 1, AC, 0.5, EXECUTE**.
2. Turn current (I_A) ON; **ON, EXECUTE**. Using Ramp Arrow keys ramp current channel up or down to find minimum pickup.
3. Minimum pickup should be within ±10% of tap value. Refer to relay instruction manual for adjustment to relay.

GFD - MINIMUM PICKUP

1. Connect monitor circuit to relay binding posts 2 and 16.
2. Set PULSAR current (I_B) equal to tap value; **CURRENT, 1, AC, 0.5, EXECUTE.**
3. Turn current (I_B) ON; **ON, EXECUTE**. Using Ramp Arrow keys ramp current channel up or down to find minimum pickup.
4. Minimum pickup should be within ±10% of tap value. Refer to relay instruction manual for adjustment to relay.

Testing of Westinghouse Type CO Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 51
Function: Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CO protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-101-Q
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CO is an induction type single-phase, non directional overcurrent relay. The CO is primarily used as phase or ground overcurrent protection of feeders, transmission lines, ac generators, transformers, capacitors, reactors, and other application where a relay is required whose operating time inversely is related to operating current.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

The CO relay test is generic, the test parameters are 2A tap and 20A instantaneous unit. Your tap values may be different. Some relays may require that current channels be paralleled to increase VA or total current, i.e., 40 A instantaneous will require two current channels 20 amperes each (see Operating Procedures, Section 1.1, Current Sources - Parallel Operation). If more current or Volt-Amperes are needed, see Description of Controls, paragraph 1.6, High Current Interface Module and EPOCH-20/II Specifications. Assign current sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	9	8	I_A	2	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST

1. Set I_A equal to tap value; **CURRENT, 1, AC, 2, ON, EXECUTE.** Note that disk is starting to creep.
2. Using the Ramp Arrow keys ramp I_A up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate (Timer Terminal 2).
2. Set I_A equal to fault current level(s) i.e., 2X; **CURRENT, 1, AC, 4, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Upon contact closure of CO contacts the Timer should stop and output turn off. Record the trip time.

INSTANTANEOUS TEST

1. Move monitor circuit to terminals 10 and 2.

2. Set I_A equal to 20A **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**
3. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A RAMP Key 1 and the **OFF, EXECUTE, ON, EXECUTE** sequential commands. When relay operates, the output will automatically turn off.
4. Record pickup value. Reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE**.

Testing of Westinghouse Type CRN-1 Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 32
Function: Directional Power

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CRN-1 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-251.2K
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CRN-1 relay is a single phase directionally controlled timing relay used to protect ac generators from motoring. When such a condition occurs and persists for a predetermined time interval, the generator may be tripped or an alarm sounded.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs OFF before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The CRN-1 relay is a single phase directionally controlled timing relay used to protect a-c generators from motoring. The relay consists of a directional unit and a timing unit.

Test Connections:

Potentials: 6 and 7, polarity on 6.
Currents: 8 and 9, polarity on 9.
Contacts: 1 and 10.

Westinghouse
CRN-1

[Front view of the relay with the test plug inserted]

2	4	6	8	10
1	3	5	7	9

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	6	7	V_A	*	0°	60.0
MON	10	1				

MINIMUM PICKUP

1. Block directional unit contacts closed.
2. Set V_A equal to 50% of rated voltage; **VOLTAGE, 1, AC, 60, EXECUTE.**
3. Initiate V_A ON; **ON, EXECUTE**. Using Ramp Arrow keys ramp V_A up or down to find minimum pickup.
4. Minimum pickup should be within ±3% of acceptance value where: Minimum Pickup = (54% * Rated Voltage).
5. De-initiate V_A; **OFF, EXECUTE.**
6. Refer to relay instruction manual for adjustment to relay for minimum pickup.

TIMING TEST

1. Block directional unit contacts closed.
2. Move monitor terminals to timer stop gate binding post (Timer Terminal 2).
3. Set V_A equal to desired test voltage (i.e. 120 volts) and test to find correct timing value; **VOLTAGE, 1, AC, 120, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. When relay trips, output will turn off and Timer will stop. Repeat test for other voltage values.
5. Timing accuracy should be within ±5% of rated fault values. Refer to relay instruction manual for adjustment to relay for assure accurate timing.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	6	7	V_A	120	0°	60.0
I_A	9	8	I_A	4	0°	60.0
MON	10	1				

DIRECTIONAL UNIT, MAXIMUM TORQUE ANGLE

1. Set V_A to rated voltage at 0°, turn VA ON; **VOLTAGE, 1, AC, 120, ON, EXECUTE.**
2. Set I_A to 4 amperes at 0°; **CURRENT, 1, AC, 4, EXECUTE.**
3. Initiate I_A ON; **CURRENT, 1, ON, EXECUTE.** CRN-1 relay contacts should be closed. Adjust (I_A) phase angle to 240° (current leads voltage 120°); **CURRENT, 1, PHASE, 240, EXECUTE**. Relay contacts should be closed. Using Ramp Arrow keys, an increase of 1° leading, (239°), should cause the CRN-1 contacts to open. If contacts open greater than 1°, adjustment is required. Refer to instruction manual for proper adjustment to the back resistor.
4. De-initiate PULSAR current and voltage channels; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE**. Perform this sequence whenever adjustment to relay is required or when test is completed.

DIRECTIONAL UNIT, SENSITIVITY

1. Set PULSAR voltage channel V_A to rated voltage at 0°, turn V_A ON; **VOLTAGE, 1, AC, 120, ON, EXECUTE**.
2. Set current I_A to 330° and turn current ON; **CURRENT, 1, PHASE, 330, AC, 0, ON, EXECUTE**. Using Ramp Arrow keys ramp current up from 0.0 amps at 330° until CRN-1 relay contacts close. Record this current reading. Typical pickup value is .020 Amperes.
3. De-initiate PULSAR current and voltage channels; **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

Testing of Westinghouse CV Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 59
Function: Overvoltage Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CV protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-201.2D
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CV is a single phase overvoltage relay used in protection schemes for sensitive overvoltage or undervoltage ground detection for high impedance grounded generators or for ungrounded power systems.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	9	8	V_A	55	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 55, ON, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A up or down until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage i.e., 55 volts; **VOLTAGE, 1, AC, 55, ON, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage at 110%; **VOLTAGE, 1, AC, 60.5, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. When relay trips, it will stop the Timer and turn outputs off. Record the timing pickup value. Repeat testing sequence for any additional fault values. Reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**

Testing of Westinghouse Type CVE Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 25
Function: Synchronizing

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the CVE and CVE-1 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-681.P
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The CVE is a synchro-verifier relay and the CVE-1 is a synchro-verifier relay with line and bus voltage sensing relays. The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The relay's contacts will close when these voltages are within the relay's set limits.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The CVE is a synchro-verifier relay.
This relay will require two potentials with phase shifting capability.

Test Connections:

Potentials: 6 and 7, polarity on 7. 8 and 9 polarity on 9.

Contacts: 1 and 10

Westinghouse CVE

[Front view of the relay with the test plug inserted]

2	4	6	8	10
1	3	5	7	9

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign voltage sources as indicated in the preset conditions table. The test values are based upon a 20° closing angle relay setting.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	6	7	V_A	120	0°	60.0
V_B	9	8	V_B	120	0°	60.0
MON	10	1				

CENTERING CIRCLE (CVE)

1. Set PULSAR voltage channel V_A and V_B to rated voltage at 0°, turn V_A and V_B ON; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp the phase angle for V_B in the lagging direction, (0° to 20°); **VOLTAGE, 2, PHASE, EXECUTE** until the contacts open, record this value. Ramp the phase angle in the, opposite, leading direction, (0° to 340°), until the contacts open a second time, record this value.
3. If the two angles are not within ±1° of each other, adjustment must be made to center the CVE. Refer to instruction manual for proper adjustment to the resistor.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, EXECUTE** whenever adjustment is required to the relay or the test is completed.

TIMING TEST

1. Move monitor circuit to timer stop gate on PULSAR.
2. Set PULSAR voltage channels V_A and V_B to rated voltage at 0°; **VOLTAGE, 1, 2, AC, 120, PHASE, 0, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. When relay trips, Timer will stop and outputs will turn off. Record timing value.
4. Repeat test as necessary.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5&7	4	V_A	120	0°	60.0
V_B	6	8	V_B	120	0°	60.0
MON	10	1				

CENTERING CIRCLE (CVE-1) without COMMONED POTENTIAL COILS

1. Set PULSAR voltage channel V_A and V_B to rated voltage at 0°, turn V_A and V_B ON; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp the phase angle for V_B in the lagging direction, (0° to 20°), **VOLTAGE, 2, PHASE, EXECUTE,** until the contacts open, record this value. Ramp the phase angle in the, opposite, leading direction, (0° to 340°), until the contacts open a second time, record this value.
3. If the two angles are not within ±1° of each other, adjustment must be made to center the CVE. Refer to instruction manual for proper adjustment to the resistor.
4. De-initiate PULSAR whenever adjustment is necessary or when test is completed; **VOLTAGE, 1, 2, OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate on PULSAR.
2. Set PULSAR voltage channels V_A and V_B to rated voltage at 0°; **VOLTAGE, 1, 2, AC, 120, PHASE, 0, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. When relay trips, Timer will stop and outputs will turn off. Record timing value.
4. Repeat test as necessary.

Testing of General Electric Type GCX Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 21
Function: Distance Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the GCX51A and GCX51B protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — GEI-98328

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The GCX51A and GCX51B relays are single-phase, three-zone phase distance relays. The first and second zone distance measurements are made by a unit having a reactance or ohm characteristic while the third zone has a directional mho characteristic. The GCX51A and GCX51B relays are identical except that the GCX51B contains an instantaneous overcurrent fault detector while the GCX51A does not.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

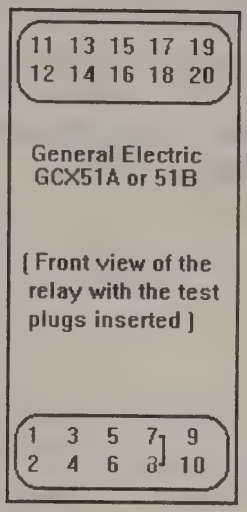
ALWAYS TEST THIS RELAY IN ITS CASE.

The GCX51A and GCX51B relays are single phase, three zone phase distance relays. This relay will be tested with a single potential and a current source.

Test Connections:

Potentials: 17 and 18, polarity on 17.
Currents: Jumper 7 to 8, in 5 and out (common) 10.

Contacts: Z1, 1 and 11, Z2, 2 and 11, Z3, 3 and 11.
OX unit: 12 (+) and 13 (-) for Z2 p.u.
GCX51B Overcurrent
Current: 5 and 6.
Contacts: 2 and 11.


11 13 15 17 19
12 14 16 18 20
General Electric
GCX51A or 51B
[Front view of the relay with the test plugs inserted]
1 3 5 7 9
2 4 6 8 10

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

Jumper relay terminals 7 to 8.

All test values are based upon a 60° maximum torque angle and the following formula:

$$Z = \frac{V}{2xI}$$

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	17	18	V_A	35	0°	60.0
I_A	5	10	I_A	5	60°	60.0
MON	*	*				
Z1 = 3Ω	Z2 = 4Ω		Z3 = 5Ω			

OHMIC REACH-ZONE 1

1. Connect the Monitor circuit to the appropriate relay contacts.
2. Set I_A to 5A and 60°, set V_A to 35v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60 , VOLTAGE, 1, AC, 35, EXECUTE.**
3. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.** Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value,refer to the GCX51 I.L. for any adjustment.
5. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

OHMIC MAXIMUM TORQUE ANGLE-ZONE 1

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (± 30°) and repeat the procedure used to determine the reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90°,(± 30° of MTA), set V_A to 35v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 35, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value, refer to the GCX51 I.L. for any adjustment.
4. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.
5. Repeat the same test steps for the 30° angle (± 30 of MTA).

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	17	18	V_A	45	0°	60.0
I_A	5	10	I_A	5	60°	60.0
MON	*	*				
Z1 = 3Ω	Z2 = 4Ω		Z3 = 5Ω			

OHMIC REACH-ZONE 2

1. Connect the monitor circuit to the appropriate relay contacts.
2. Manually close the OX unit or connect 125 vdc to terminals 12 (+) and 13 (-) to pickup the OX unit needed to do the Zone 2 tests.
3. Set I_A to 5A and 60°, set V_A to 45v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60, VOLTAGE, 1, AC, 45, EXECUTE**.
4. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys, ▲,▼, ramp V_A until the contacts pickup.
5. Record the pickup value, refer to the GCX51 I.L. for an adjustment.
6. Turn I_A and V_A OFF, whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.

OHMIC MAXIMUM TORQUE ANGLE-ZONE 2

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (±30° of MTA) and repeat the procedure used to determine reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90° (±30° of MTA), set V_A to 45v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 45, EXECUTE**.
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys, ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value, refer to the GCX51 I.L. for any adjustment.
4. Turn I_A and V_A OFF, whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.
5. Repeat the same test steps for the 30° angle (±30° of MTA).

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	17	18	V_A	55	0°	60.0
I_A	5	10	I_A	5	60°	60.0
MON	*	*				
Z1 = 3Ω	Z2 = 4Ω		Z3 = 5Ω			

OHMIC REACH - MHO UNIT

1. Connect the Monitor circuit to the appropriate relay contacts.
2. Set I_A to 5A and 60°, set V_A to 55V and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60 , VOLTAGE, 1, AC, 55, EXECUTE.**
3. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.** Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value,refer to the GCX51 I.L. for any adjustment.
5. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

MAXIMUM TORQUE ANGLE - MHO UNIT

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (±30° of MTA) and repeat the procedure used to determine reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90°,(± 30° of MTA), set V_A to 55V and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 55, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value, refer to the GCX51 I.L. for any adjustment.
4. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.
5. Repeat the same test steps for the 30° angle (± 30 of MTA).

OVERCURRENT UNIT PICKUP - GCX51B

1. Connect I_A to GCX51B relay terminals 5 and 6 respectively.
2. Connect monitor binding posts to relay terminals 2 and 11.
3. Set I_A equal to tap value at 0° and initiate I_A; **CURRENT, 1, PHASE, 0, AC, 5, ON, EXECUTE.**
4. Using the Ramp Arrow keys ramp current up or down to find minimum pickup.
5. Record value and refer to GCX51B instruction manual for adjustment.
6. De-initiate PULSAR; **CURRENT, 1, OFF, EXECUTE.**

Testing of General Electric Type GCY Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 21
Function: Distance Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the GCY51A protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEI-98338
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The GCY51 relay is a single-phase, three zone, expanded range, directional mho step distance relay for transmission line protection, phase distance relays. The GCY51 relay is used in combination with other relays and pilot channels to provide high speed protection in directional comparison and transferred tripping schemes.

PRECAUTIONS

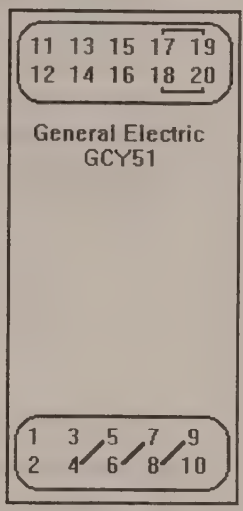
**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The GCY is a single phase, three zone directional mho step distance relay.
This relay will be tested with a single potential and a current source.
Potentials: Jumper 17-19,18-20 polarity on 17.
Currents: Jumper 4-5,6-7,8-9, polarity on 3 and out (common) on 10.
contacts: M1 - 1 to 11, M2 - 2 to 11, and M3 - 11 to 12.



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

Jumper relay terminals 4 to 5, 6 to 7, 8 to 9, 17 to 19, 18 to 20.

All test values are based upon a 60° maximum torque angle, 50 Reach, and the following formula:

$$Z = \frac{V}{2xI}$$

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	17	18	V_A	55	0°	60.0
I_A	3	10	I_A	5	60°	60.0
MON	1	11				
* = Value depends on offset tap						

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

REACH TEST

1. Connect the Monitor circuit to the appropriate relay contacts.
2. Set I_A to 5A and 60°, set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 60 , VOLTAGE, 1, AC, 55, EXECUTE.**
3. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE.** Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup value,refer to the GCY51 I.L. for any adjustment.
5. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**

MAXIMUM TORQUE ANGLE

Note: To determine maximum angle of torque, adjust the phase angle equisdistance either side of the maximum angle of torque (± 30°) and repeat the procedure used to determine the reach. The two points should be equal, if the maximum angle of torque is correct.

1. Set I_A to 5A and 90°,(± 30° of MTA), set V_A to 55v and 0°, using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 90, VOLTAGE, 1, AC, 55, EXECUTE.**
2. Initiate PULSAR; **CURRENT, 1, ON, VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
3. Record the pickup value, refer to the GCY51 I.L. for any adjustment.
4. Turn I_A and V_A, OFF whenever an adjustment is required or the test is completed. **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE.**
5. Repeat the same test steps for the 30° angle (± 30° of MTA).

OFFSET

1. Set I_A to 5A and 240°, (180° opposite MTA), set V_A equal to (*)+10% above the expected pickup using the following keystrokes; **CURRENT, 1, AC, 5, PHASE, 240, VOLTAGE, 1, AC, (*), EXECUTE**.
2. Initiate PULSAR; **CURRENT, 1, VOLTAGE, 1, ON, EXECUTE**.
3. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A until the contacts pickup.
4. Record the pickup and refer to the GCY51 I.L. for any adjustment.
5. Turn V_A and I_A, OFF whenever an adjustment is required or the test is completed; **CURRENT, 1, VOLTAGE, 1, OFF, EXECUTE**.

Testing of General Electric Type GGP Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 32
Function: Power Directional Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the GGP53C protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-34117C
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The GGP53C is a polyphase power directional relay used in protection schemes for sensitive anti-motoring protection for steam turbine generators. The relay consists of a time delay overvoltage unit (top unit) and a three-phase directional unit (bottom unit).

PRECAUTIONS

**********WARNING**********

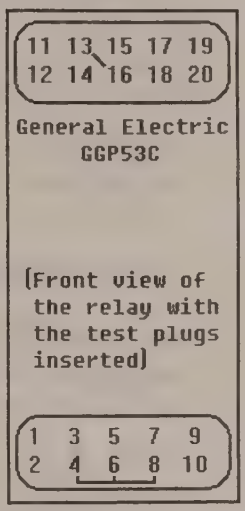
Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The GGP53C is polyphase power directional relay used in protection schemes for sensitive anti-motoring protection for steam turbine generators. The relay consists of a time delay overvoltage unit (top unit) and a three-phase directional unit (bottom unit).

(*) for I_A, I_B, I_C are .01 amperes (10 milliamperes).



PULSAR TEST CONDITIONS						
Assign	Connect		Test	Values		Hz
	±	N			∠	
V_A	14		V_A	69.2	0°	60.0
V_B	13		V_B	69.2	120°	60.0
V_C	15		V_C	69.2	240°	60.0
I_A	3		I_A*	.01	180°	60.0
I_B	5		I_B*	.01	300°	60.0
I_C	7		I_C*	.01	60°	60.0
MON	TB1-9	TB1-10				

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For Pick Up and Timing Test, assign current and voltage sources as indicated in the preset conditions table below.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	12	2	V_A	*	0°	60.0
MON	1	11				

PICKUP TEST (TOP UNIT)

1. Set V_A equal to 40% of rated voltage and turn V_A on using the following keystrokes; **VOLTAGE, 1, AC, 48, ON, EXECUTE** (use 48 or 83 volts for 120 or 208 volt relays respectively).
2. Ramp V_A up using the appropriate ▲ RAMP key until the contacts pickup.
3. Record the minimum pickup value (normally 50 % of rated voltage ± 3 %).
4. Turn V_A OFF by pressing; **OFF, EXECUTE**.

TIMING TEST (TOP UNIT)

1. Set V_A to rated voltage by using the following keystrokes; **VOLTAGE, 1, AC, 120 (or 208), EXECUTE**. NOTE: The output should not be ON yet.
2. Move monitor circuit to timer stop gate, (T2). Set output to turn off when the relay trips by using the following keystrokes; **Shift, A-OFF, ON, EXECUTE**.
3. Initiate V_A and start the Timer using the following keystrokes; **ON, TIMER START, EXECUTE**.
4. Record the timing pickup value. Repeat testing sequence for any additional time dial settings.
5. De-initiate V_A if Auto-off feature was not used by pressing, **OFF, EXECUTE**.

PICK UP OF DIRECTIONAL UNIT (BOTTOM UNIT)

1. With reference to figure 10, GEK-34117, jumper GGP terminals 4 to 6 to 8, and jumper terminal 13 to 16.

2. Assign current and voltage sources as indicated in the following preset conditions table. The test values defined with the (*) for I_A, I_B, and I_C are .01 amperes (10 milliamperes). The typical pickup value is 10 milliamperes. The pickup may be adjusted as high as 40 milliamperes. The voltage preset values are for a 120 volt phase-to-phase rated relay. To set the three voltage and current output amplitudes use the following keystrokes; **VOLTAGE, 0, AC, 69.2, CURRENT, 0, AC, .01, EXECUTE**. To set phase angles use the following keystrokes; **VOLTAGE 2, CURRENT, 2, PHASE, 120, VOLTAGE 3, CURRENT, 3, PHASE, 240, EXECUTE**. To adjust the three current channels to the proper phase angle relationship, use the following keystrokes; **CURRENT, 0, PHASE**, press and hold the appropriate ▲ RAMP key until 180° is displayed on I_A. Note that I_B and I_C should now be at their respective phase angles as shown below.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	14		V_A	69.2	0°	60.0
V_B	13		V_B	69.2	120°	60.0
V_C	15		V_C	69.2	240°	60.0
I_A	3		I_A*	.01	180°	60.0
I_B	5		I_B*	.01	300°	60.0
I_C	7		I_C*	.01	60°	60.0
MON	TB1-9	TB1-10				

3. Initiate all voltage and current channels using the following keystrokes; **VOLTAGE, 0, CURRENT, 0, ON, EXECUTE**. All output channels should be ON.
4. Ramp currents up or down to determine minimum pickup value using the following keystrokes; **CURRENT, 0, AC**, and press the least significant ▲ or ▼ RAMP key to increment currents in milliamperes.
5. Record the minimum pickup value.
6. Reverse the phase angle to I_A, I_B, and I_C the directional contacts should have a restraining torque. To reverse the phase angle use the following keystrokes; **CURRENT, 0, PHASE**, and press the appropriate ▲ RAMP key until 0° is displayed on I_A. I_B and I_C should now be at their respective phase angles of 120° and 240°.

7. De-initiate all voltage and current channels by using the following keystrokes; **VOLTAGE, 0, CURRENT, 0, OFF, EXECUTE**.

Testing of Westinghouse Type HU and HU-1 Relays

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 87
Function: Transformer Differential

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the HU protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — I.L. 41-347.1Q

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The HU relay is a high-speed relay used in the differential protection of transformers. These relays can be applied where the magnetizing inrush current to the transformer is severe. The HU relay has two restraint transformers and two rows of taps. The HU relay has a differential unit a harmonic restrain unit, an indicating contactor switch unit and instantaneous trip unit.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Always apply a POLARIZE Current of 90 Amps before each test.

Assign current and voltage sources as indicated in the preset conditions table. The test values are based upon a 5A tap and 20% slope relay setting.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	1.2	0°	60.0
I_B	7	3	I_B	1.2	0°	60.0
MON	10	1				

MINIMUM PICKUP

1. Block the Harmonic Restraint contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE**.
3. Set PULSAR current channels to test parameters equal to (tap * 0.3) value; **CURRENT, 1, 2, AC, 1.2, EXECUTE.**
4. Turn current (I_A) ON; **CURRENT, 1, AC, ON, EXECUTE**. Using RAMP Arrow keys, ramp current channel up or down to find minimum pickup. Turn I_A OFF; **CURRENT, 1, OFF, EXECUTE**. Repeat test for current I_B, all commands for I_B are CURRENT, 2.
5. Minimum pickup should be within ±10% of (tap * 0.3) value. Refer to relay instruction manual for adjustment to minimum pickup resistor.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	7	I_A	25	0°	60.0
MON	10	1				

THROUGH FAULT RESTRAINT

1. Block the Harmonic Restraint contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE**. After Polarization reset **A-OFF; SHIFT, A-OFF, OFF, EXECUTE**.
3. Set PULSAR current channels to test parameters with current channel I_A equal to 25 amperes, turn current I_A ON; **CURRENT, 1, AC, 25, ON, EXECUTE**. HU relay should be in restraint, (relay's main trip contacts remain open rather than close).
4. Turn current OFF; **CURRENT, 1, OFF, EXECUTE**. Disconnect relay and set up for Harmonic restraint test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	7	0°	60.0
I_B	5	3	I_B	1	0°	120.0
MON	10	1				

HARMONIC RESTRAINT using pure 2nd Harmonic Current

1. Block the Differential Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set I_A and I_B on PULSAR to above parameters; **CURRENT, 2, AC, 1, FREQ, 120, SHIFT, RST_PH, ON, CURRENT, 1, AC, 7, ON, EXECUTE**.

4. Using the Ramp Arrow keys ramp I_A up or down to find pickup of harmonic restraint trip contact.
5. Record value.
6. De-initiate PULSAR if adjustment to HU relay is necessary; **CURRENT, O, OFF, EXECUTE.**
7. Calculate percent harmonic with the formula as referred to under Current Sources-Harmonic Restraint Test.
8. When test is complete, reset frequency to 60 Hz on I_B; **CURRENT, 2, FREQ, 60, SHIFT, RST_PH, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	7	0°	60.0
I_B	5	3	I_B	8.89	0°	60.0
MON	10	1				

HARMONIC RESTRAINT using H_WAVE (Diode Test Method)

1. Block the Differential Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set I_A and I_B on PULSAR to above parameters with I_B to 8.89A, H_WAVE, to establish 4A I_{dc} (as required for diode test method), refer to section Current Sources-Harmonic Restraint Test.; **CURRENT, 2, AC, 8.89, SHIFT, H_WAVE, SHIFT, RST_PH, ON, CURRENT, 1, AC, 7, ON, EXECUTE.**
4. Using the Ramp Arrow keys ramp I_A up or down to find pickup of harmonic restraint trip contact.
5. Record value.
6. De-initiate PULSAR if adjustment to HU relay is necessary; **CURRENT, 0, AC, OFF, EXECUTE.**
7. Refer to the manufacturers instruction literature for the appropriate % Harmonic Curve.
8. When test is complete, restore sine wave; **CURRENT, 0, SHIFT, SINE, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	2	0°	60.0
I_B	5	7	I_B	10	0°	60.0
MON	10	1				

SLOPE TEST

1. Block the Harmonic Restraint Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set I_A equal to 2 amperes and I_B equal to 10 amperes; **CURRENT, 2, AC, 10, ON, CURRENT, 1, AC, 2, ON, EXECUTE.**
4. Using Ramp Arrow keys ramp I_A up or down until main trip contacts pickup. Record pickup value. De-initiate PULSAR I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE.**
5. Using the formula; %Slope = $(I_A/I_B)*100$, calculate the actual HU slope characteristics. Refer to the I.L. for tolerances.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	25	0°	60.0
I_B	5	3	I_B	25	0°	60.0
MON	10	2				

INSTANTANEOUS TEST

1. Set I_A and I_B equal to (10 * 5A tap); **CURRENT, 1,2, AC, 25, SHIFT, A-OFF, ON, EXECUTE.**
2. Turn both I_A and I_B ON; **CURRENT, 1, 2, ON, EXECUTE**. Pulse I_A and I_B up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands.
3. Record pickup value.
4. De-initiate PULSAR I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE.**

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 87
Function: Transformer Differential

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the HU-1 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — I.L. 41-347.1Q

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The HU relay is a high-speed relay used in the differential protection of transformers. These relays can be applied where the magnetizing inrush current to the transformer is severe. The HU-1 relay has three restraint transformers and three rows of taps. The HU-1 relay has a differential unit, a harmonic restrain unit, an indicating contactor switch unit and instantaneous trip unit.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE .

SETUP AND PROCEDURE

For each test:

Always apply a POLARIZE Current of 90 Amps before each test.

Assign current and voltage sources as indicated in the preset conditions table. The test values are based upon a 5A tap and 20% slope relay setting.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	1.2	0°	60.0
I_B	7	3	I_B	1.2	0°	60.0
I_C	9	3	I_C	1.2	0°	60.0
MON	10	1				

MINIMUM PICKUP

1. Block the Harmonic Restraint contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE**. After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set PULSAR current channels to test parameters equal to (tap * 0.3) value; **CURRENT, 1, 2, AC, 1.2, EXECUTE.**
4. Turn current (I_A) ON; **CURRENT, 1, AC, ON, EXECUTE.** Using RAMP Arrow keys, ramp current channel up or down to find minimum pickup. Turn I_A OFF; **CURRENT, 1, OFF, EXECUTE**. Repeat test for current I_B, all commands for I_B are CURRENT, 2.
5. Minimum pickup should be within ±10% of (tap * 0.3) value. Refer to relay instruction manual for adjustment to minimum pickup resistor.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	7	I_A	25	0°	60.0
I_B	9	7	I_B	25	0°	60.0
MON	10	1				

THROUGH CURRENT RESTRAINT

1. Block the Harmonic Restraint contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set PULSAR current channels to test parameters with current channel I_A equal to 25 amperes, turn current I_A ON; **CURRENT, 1, AC, 25, ON, EXECUTE**. HU relay should be in restraint, (relay's main trip contacts remain open rather than close).
4. Turn current OFF; **CURRENT, 1, OFF, EXECUTE**. Disconnect relay and set up for Harmonic restraint test.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	7	0°	60.0
I_B	5	3	I_B	1	0°	120.0
MON	10	1				

HARMONIC RESTRAINT using pure 2nd Harmonic Current

1. Block the Differential Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**

3. Set I_A and I_B on PULSAR to above parameters; **CURRENT, 2, AC, 1, FREQ, 120, SHIFT, RST_PH, ON, CURRENT, 1, AC, 7, ON, EXECUTE.**
4. Using the Ramp Arrow keys ramp I_A up or down to find pickup of harmonic restraint trip contact.
5. Record value.
6. De-initiate PULSAR if adjustment to HU relay is necessary; **CURRENT, O, OFF, EXECUTE.**
7. Calculate percent harmonic with the formula as referred to under Current Sources-Harmonic Restraint Test.
8. When test is complete, reset frequency to 60 Hz on I_B; **CURRENT, 2, FREQ, 60, SHIFT, RST_PH, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	7	0°	60.0
I_B	5	3	I_B	8.89	0°	----
MON	10	1				

HARMONIC RESTRAINT using H_WAVE (Diode Test Method)

1. Block the Differential Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set I_A and I_B on PULSAR to above parameters with I_B to 8.89A, H_WAVE, to establish 4A I_{dc} (as required for diode test method), refer to section Current Sources-Harmonic Restraint Test.; **CURRENT, 2, AC, 8.89, SHIFT, H_WAVE, SHIFT, RST_PH, ON, CURRENT, 1, AC, 7, ON, EXECUTE.**
4. Using the Ramp Arrow keys ramp I_A up or down to find pickup of harmonic restraint trip contact.
5. Record value.
6. De-initiate PULSAR if adjustment to HU relay is necessary; **CURRENT, 0, OFF, EXECUTE.**
7. Refer to the manufacturers instruction literature for the appropriate % Harmonic Curve.
8. When test is complete, restore sine wave; **CURRENT, 0, SHIFT, SINE, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	2	0°	60.0
I_B	5	7	I_B	10	0°	60.0
I_C	9	3	I_C			
MON	10	1				

SLOPE TEST

1. Block the Harmonic Restraint Unit contacts closed.
2. Polarize HU relay with 90 amps across restraint windings 5 and 3. Connect I_C in parallel with I_A and I_B; **CURRENT, 0, AC, 30, ON, SHIFT, A-OFF, ON, EXECUTE.** After Polarization reset A-OFF; **SHIFT, A-OFF, OFF, EXECUTE.**
3. Set I_A equal to 2 amperes and I_B equal to 10 amperes; **CURRENT, 2, AC, 10, ON, CURRENT, 1, AC, 2, ON, EXECUTE.**
4. Using Ramp Arrow keys ramp I_A up or down until main trip contacts pickup. Record pickup value. De-initiate PULSAR I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE.**
5. Using the formula; %Slope = $(I_A/I_B)*100$, calculate the actual HU slope characteristics. Refer to the I.L. for tolerances.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	3	I_A	25	0°	60.0
I_B	5	3	I_B	25	0°	60.0
I_C			I_C			
MON	10	1				

INSTANTANEOUS TEST

1. Set I_A and I_B equal to (10 * 5A tap); **CURRENT, 1,2, AC, 25, SHIFT, A-OFF, ON, EXECUTE.**

2. Turn both I_A and I_B ON; **CURRENT, 1, 2, ON, EXECUTE.** Pulse I_A and I_B up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands.
3. Record pickup value.
4. De-initiate PULSAR I_A and I_B OFF; **CURRENT, 1, 2, OFF, EXECUTE.**

Testing General Electric Type IAC Relays

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 51
Function: Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IAC protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-34053D
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IAC are single-phase, current operated, ac devices with inverse time current characteristics. The IAC are utilized to protect commercial, industrial, and utility power distribution systems against either multi-phase or phase to ground faults.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

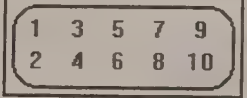
The type IAC relays comprise of a group of relays that are employed to protect against overcurrent on single phase and polyphase circuits. These relays consist of an induction unit or an induction unit with an instantaneous unit.

Test Connections:

Currents: 5 and 6.

Contacts: Toc, 1 and 2
Ioc, 1 and 3

General Electric
IAC
[Front view of the relay with the test plug inserted]



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

The IAC relay test is generic, the test parameters are 2A tap and 20A instantaneous unit. Your tap values may be different. Some relays may require that current channels be paralleled to increase VA or total current, i.e., 40A instantaneous will require two current channels 20 amperes each (see Operating Procedures, Section 1.1, Current Sources - Parallel Operation). If more current or Volt-Amperes are needed, see Description of Controls, paragraph 1.6, High Current Interface Module and EPOCH-20/II Specifications. Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	6	I_A	2	0°	60.0
MON	1	2				

MINIMUM PICKUP TEST

1. Set I_A equal to tap value; **CURRENT, 1, AC, 2, ON, EXECUTE.** Note that the disk should be starting to move (creep).
2. Using the Ramp Arrow keys ramp I_A up and down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate.
2. Set I_A equal to fault current level(s) i.e., 2x tap, and set output to turn off when relay trips using; **CURRENT, 1, AC, 4, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Upon contact closure of IAC contacts, record the timing value.

4. Repeat tests as necessary for example;
CURRENT, 1, AC, 6, ON, TIMER START, EXECUTE.
CURRENT, 1, AC, 8, ON, TIMER START, EXECUTE.
CURRENT, 1, AC, 10, ON, TIMER START, EXECUTE.
NOTE: Allow disk to completely reset after each timing test.

INSTANTANEOUS TEST

1. Move monitor circuit to terminals 1 and 3.
2. Set I_A equal to 20A ; **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**
3. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands. When relay trips, output will automatically turn off.
4. Record pickup value.

Testing General Electric IAV Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 59
Function: Overvoltage Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IAV protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEH-1814C
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IAV is a single phase overvoltage relay used in protection schemes for sensitive overvoltage ground detection for high impedance grounded generators or for ungrounded power systems.

NOTE: Some IAV relays are designed to operate at frequencies and voltages other than those described here. For example, 25 Hz relays and 460 volt relays. For testing 25 Hz relays, the operator will need to select a new output frequency, see Operating Procedures, Testing Frequency Relays. For output voltages in excess of 300 volts see, Voltage Sources - Outputs Summed Together.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

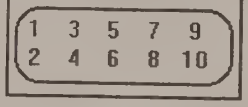
ALWAYS TEST THIS RELAY IN ITS CASE.

The IAV is a single phase overvoltage relay used in protection schemes for sensitive overvoltage ground detection for high impedance grounded generators or for ungrounded power systems.

Test Connections:

Potential: 5 and 6, polarity on 5.
Contact: 1 and 2.

General Electric
IAV
(Front view of the relay with the test plug inserted)



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O	O O	O O
	AMPS		AMPS		AMPS
	O O		O O		O O

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	6	V_A	55	0°	60.0
MON	1	2				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate i.e., 55 volts; **VOLTAGE, 1, AC, 55, ON, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A up or down until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage; **VOLTAGE, 1, AC, 55, ON, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage at 110%, output turn off and Timer Stop when relay trips; **VOLTAGE, 1, AC, 60.5, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. Record the timing value. Repeat testing sequence for any additional fault values.

Testing General Electric Type IJF Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 81
Function: Frequency Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IJF protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEI-19008E
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IJF is a single phase induction disk relay used in protection schemes against the effects of overfrequency or underfrequency.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

The IJF relay used is an IJF52A relay with both overfrequency and underfrequency characteristics. For this example procedure, the underfrequency setting is 58 Hz and the overfrequency setting is 62 Hz.

Assign voltage sources as indicated in the preset conditions table.

Underfrequency Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	6	V_A	115	0°	60.0
MON	1	2				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 115, ON, SHIFT, SZ, FREQ, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A frequency down until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage and frequency (if you have just completed the Pickup Test, press ON, EXECUTE go to step 2); **VOLTAGE, 1, AC, 115, FREQ, 60, ON, SHIFT, SZ, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage and fault frequency 58 Hz and turn output off when relay trips; **VOLTAGE, 1, AC, 110, FREQ, 58, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. Record the timing value. Repeat testing sequence for any additional fault values.
5. If you need to test Overfrequency go to next test. If all tests have been completed on the relay, reset the PULSAR to original default settings by pressing the RESET button on the Input Power Control Module.

Overfrequency Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	8	V_A	115	0°	60.0
MON	1	2				

MINIMUM PICKUP TEST

1. Set V_A equal to test parameters and initiate; **VOLTAGE, 1, AC, 115, ON, FREQ, SHIFT, SZ, EXECUTE.**
2. Using Ramp Arrow keys ramp V_A frequency up until main trip contacts pickup.
3. Record the minimum pickup value.
4. De-initiate V_A; **VOLTAGE, 1, OFF, EXECUTE.**

TIMING TEST

1. Set V_A to normal voltage and frequency (if you have just completed pickup test, press ON, EXECUTE go to step 2); **VOLTAGE, 1, AC, 115, FREQ, ON, SHIFT, SZ, EXECUTE.**
2. Move monitor circuit to timer stop gate.
3. Set V_A equal to fault voltage and fault frequency 62 Hz and turn output off when relay trips; **VOLTAGE, 1, AC, 110, FREQ, 62, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
4. Record the timing pickup value. Repeat testing sequence for any additional fault values.
5. If all tests have been completed on the relay, reset the PULSAR to original default setting by pressing the RESET button on the Input Power Control Module.

Testing General Electric Type IJS Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 25
Function: Synchronizing

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IJS protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEH-1791
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IJS is a synchro-verifier relay with line and bus voltage sensing. The synchro-verifier is used to verify the condition of synchronism existing between two system voltages. The relay's contacts will close when these voltages are within the relay's set limits.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The IJS51D is a synchronism-check relay used to permit closure of a circuit breaker, provided the two sources connected to it are correctly synchronized elsewhere. This relay will require two potentials with phase shifting capability.

Test Connections:

Potentials: 5 and 6, polarity on 5. 7 and 8 polarity on 7.
contacts: 1 to 2.

General Electric
IJS51D

[Front view of the relay with the test plug inserted]

1	3	5	7	9	
2	4	6	8	10	

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign voltage sources as indicated in the preset conditions table. The test values are based upon a 20° closing angle relay setting.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	6	V_A	120	0°	60.0
V_B	7	8	V_B	120	0°	60.0
MON	1	2				

CENTERING CIRCLE (IJS)

1. Set PULSAR voltage channel V_A and V_B to rated voltage at 0°, turn V_A and V_B ON; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp the phase angle for V_B in the lagging direction, (0° to 20°); **VOLTAGE, 2, PHASE, RAMP ▲** until the contacts open, record this value. Ramp the phase angle in the, opposite, leading direction, (0° to 340°), until the contacts open a second time, record this value.
3. If the two angles are not within ±1° of each other, adjustment must be made to center the IJS. Refer to instruction manual for proper adjustment to the resistor.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, EXECUTE** whenever adjustment is required to the relay or the test is completed.

TIMING TEST

1. Move monitor circuit to timer stop gate on PULSAR.
2. Set PULSAR voltage channels V_A and V_B to rated voltage at 0° and outputs to turn off when relay trips; **VOLTAGE, 1, 2, AC, 120, PHASE, 0, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Record timing value.
4. Repeat test as necessary.

5. De-initiate PULSAR if the outputs are not off; **VOLTAGE, 1, 2, OFF, EXECUTE** whenever adjustment is required to the relay or the test is completed.

Testing Westinghouse Type IRD and IRV Relays

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 67
Function: Directional Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IRD and IRV protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-133P
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IRD is a dual polarized relay for directional ground overcurrent faults. The IRV is a directional overcurrent relay for phase protection.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

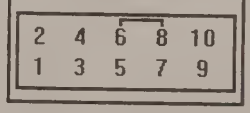
These are directional overcurrent relays types IRD,IRC,and IRP. This relay will require a single potential and current.

Test Connections:

Potentials: 4 and 5, polarity on 5.
Currents: Jumper 6-8, polarity on 9 and common on 7.
contacts: 1 to 10.

Westinghouse
IRD

{ Front view of the relay with the test plug inserted }



PULSAR

CONTROL MODULE	TIMER	VOLTS	VOLTS	VOLTS
		O O↴	O O↴	O O↴
AMPS		AMPS		AMPS
O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

The IRD relay test is generic, the test parameters are 2A tap and 20A instantaneous unit. Your tap values may be different. Some relays may require that current channels be paralleled to increase VA or total current, (see Operating Procedures, Section 1.1, Current Sources - Parallel Operation). If more current or Volt-Amperes are needed, see Description of Controls, paragraph 1.6, High Current Interface Module and EPOCH-20/II Specifications.

Jumper relay terminals 6 to 8.

Connect CS-1 unit's relay terminals 10 (+) and 3 (-) to the 125 volt dc Battery Simulator for relay simulation testing of directional overcurrent relays.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	4	5	V_A	*	0°	60.0
I_A	9	7	I_A	2	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST

1. Set I_A equal to 1.5 times tap value and initiate; **CURRENT, 1, AC, 3, ON, EXECUTE.**
2. Using Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate.
2. Set I_A equal to fault current level(s); **CURRENT, 1, AC, 4, ON, SHIFT, A-OFF, ON, EXECUTE.**
3. Upon contact closure, record the minimum pickup value.

4. Repeat tests as necessary.
5. Reset A-OFF function; **SHIFT, A-OFF, OFF, EXECUTE.**

DIRECTIONAL UNIT TEST

1. Set V_A and I_A equal to directional unit sensitivity, per I.L., Table 1 page 28. For example, an IRD with .5 to 2.5 Amp tap, the directional unit contacts should close with 1 volt and 4 amperes, in phase, applied to their respective terminals. To set in phase, 1 volt and 4 amperes: **VOLTAGE, 1, AC, 1, CURRENT, 1, AC, 4, EXECUTE**. If it is desired to test at 60° lagging then; **VOLTAGE, 1, AC, 1, CURRENT, 1, AC, 2, PHASE, 60, EXECUTE**.
2. Initiate V_A and I_A; **VOLTAGE, 1, ON, CURRENT, 1, AC, ON, EXECUTE**.
3. Ramp current up or down to determine minimum pickup value by pressing the RAMP up or down arrow keys.
4. Record the minimum pickup value.
5. De-initiate V_A and I_A; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE**.

INSTANTANEOUS OVERCURRENT PICKUP TEST

NOTE: Due to possible high impedance, it may be required to parallel two or more current channels for higher VA. See Operating procedures, Section 1.1, Current Sources - Parallel Operation. Or, use and EPOCH-20/II with High Current Interface Module, see Descriptions of Controls, paragraph 1.6 and EPOCH-20/II Specifications.

1. Connect monitor circuit to relay terminals 10 and 2.
2. Block normally open directional unit contacts closed.
3. Connect relay terminals 9(±) and 4(N) to I_A. Set I_A equal to instantaneous fault current level(s) i.e., 20 amperes and turn off output when relay triggers; **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**
4. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands.Initiate I_A, upon contact closure of contacts, record the pickup value.
5. Repeat test as necessary using on and off commands.
6. Reset A-OFF command; **SHIFT, A-OFF, OFF, EXECUTE.**

Testing General Electric Type JBC and JBCV Relays

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 67
Function: Directional Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the JBC and JBCV protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-49848 & GEK-49850
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The JBC is a phase directional overcurrent relay. The JBCV is a phase directional overcurrent relay with voltage restraint. Both relays are for phase protection.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

For this example procedure, the JBC relay test parameters are 2A tap and 20A instantaneous unit.

NOTE: Some relays may require that current channels be paralleled to increase VA or total current, see Operating Procedures, Section 1.1, Current-Sources - Parallel Operation. If more current or Volt-Amperes are needed, see Description of Controls, paragraph 1.6, High Current Interface Module and EPOCH-20/II Specifications.

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	3	4	I_A	2	0°	60.0
MON	1	11				

MINIMUM PICKUP TEST

1. Set I_A equal to tap value and initiate; **CURRENT, 1, AC, 2, ON, EXECUTE.** Note that overcurrent disk is slowly moving (creep).
2. Using Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate.
2. Set I_A equal to fault current level(s) i.e., 2x tap, and turn outputs off when the relay trips; **CURRENT, 1, AC, 4, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Upon contact closure, record the timing value.

4. Repeat tests as necessary.
5. Reset A-OFF function; **SHIFT, A-OFF, OFF, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	8	V_A	115	*	60.0
I_A	5	6	I_A	2	0°	60.0
MON	1	11				

DIRECTIONAL UNIT TEST

1. Set V_A and I_A for directional unit polarity check based on Figure 24 of instruction manual and table parameters below. Refer to Phase Angle Relationships Section. All current angles in JBC instruction manual are leading angles, those listed below are lagging angles.
2. Ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.

P.F. Angle - Lag	90-135	135-180	180-225	225-270	270-315	315-360	0-45	45-90
Power Flow KW IN/OUT	OUT	IN	IN	IN	IN	OUT	OUT	OUT

4. Contacts should be closed when KW flow is IN and open when KW flow is out.
5. De-initiate V_A and I_A; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE.**

INSTANTANEOUS OVERCURRENT PICKUP TEST

1. Connect monitor circuit to relay terminals 1 and 12.
2. Block normally open directional unit contacts closed.
3. Connect relay terminals 2(±) and 3(N) to I_A. Set I_A equal to instantaneous fault current level(s) i. e., 20 amperes and turn outputs off when relay trips; **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**
4. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands. Record the pickup value.

5. Repeat test as necessary using on and off commands.
6. Reset A-OFF command; **SHIFT, A-OFF, OFF, EXECUTE.**

Testing General Electric Type JBCG51 Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 67
Function: Directional Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the JBCG51E protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-49849A
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The JBCG51E is a ground directional overcurrent relay used primarily for the protection of feeders and transmission lines. They are available with inverse, very inverse, or extremely inverse time characteristics.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

The JBCG relay example test parameters are 2A tap and 20A instantaneous unit.

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	2	4	I_A	2	0°	60.0
MON	1	11				

NOTE: Block directional contacts closed for Overcurrent pickup and timing tests.

MINIMUM PICKUP TEST

1. Set I_A equal to tap value and initiate; **CURRENT, 1, AC, 2, ON, EXECUTE.** Note that overcurrent disk is slowly moving (creep).
2. Using Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**

OVERCURRENT TIMING TEST

1. Move monitor circuit to timer stop gate.
2. Set I_A equal to fault current level(s) i. e., 2x tap, and turn output off when relay trips; **CURRENT, 1, AC, 4, ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Upon contact closure, record the timing value.
4. Repeat tests as necessary; **ON, TIMER START, EXECUTE.**
5. Reset A-OFF function; **SHIFT, A-OFF, OFF, EXECUTE.**

NOTE: Remove blocking material from directional unit.

DIRECTIONAL UNIT CURRENT POLARIZATION TEST

1. Jumper relay terminals 6 to 7 and 9 to 10. Move MONITOR lead from 11 to 19.
2. Connect relay terminals 5(±) and 8(N) to I_A. Polarization angle is 0°.
3. Set I_A equal to .25 Amperes and initiate; **CURRENT, 1, AC, .25, ON, EXECUTE**.
4. Using Ramp Arrow keys, ramp current up to determine minimum pickup value.
5. Record minimum pickup value, de-initiate I_A; **OFF, EXECUTE**.
6. Remove jumpers.

DIRECTIONAL UNIT POTENTIAL POLARIZATION TEST

1. Connect relay terminals 9(±) and 10(N) to V_A and relay terminals 5(±) and 6(N) to I_A . Monitor terminals 1 and 19.
2. Set V_A to 5 volts and I_A .5 amperes; **VOLTAGE, 1, AC, 5, ON, CURRENT, 1, AC, .5, ON, EXECUTE.**
3. Using Ramp Arrow keys, ramp current up to determine minimum pickup.
4. Record minimum pickup, de-initiate V_A and I_A; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE**.

INSTANTANEOUS OVERCURRENT PICKUP TEST

1. Connect monitor circuit to relay terminals 1 and 12.
2. Block normally open directional unit contacts closed.
3. Connect relay terminals 2(±) and 3(N) to I_A. Set I_A equal to instantaneous fault current level(s); **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**
4. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands.Initiate I_A, upon contact closure of contacts, record the pickup value.
5. Repeat test as necessary using on and off commands.
6. Reset A-OFF command; **SHIFT, A-OFF, OFF, EXECUTE**.

Testing Westinghours Type KA Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1992 Rev: A
IEEE Device Number: 85
Function: Carrier Auxiliary

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the KA-4 protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-923.4M
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The KA-4 relay is an auxiliary relay used in the type KD directional comparison tripping system. The KA-4 provides a circuit for high-speed tripping, controls the transfer tripping signal for remote line terminals and supplies necessary coordination during power reversal conditions.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	*	*	V_A	*	dc	dc
I_A	*	*	I_A	*	0°	60.0
MON	*	*				

OVERCURRENT MINIMUM PICKUP TEST

1. Connect relay terminals 17(±) and 16(N) to I_A.
2. Set I_A at 0.2 amps; **CURRENT, 1, AC, 0.2, ON, EXECUTE.** Using the Ramp Arrow keys ramp current up until normally closed contacts 'just open' to determine minimum pickup value
3. Record the minimum carrier start value.
4. De-initiate I_A; **OFF, EXECUTE.**

CSP UNIT PICKUP TEST

1. Connect relay terminals 2(±) and 1(N) to V_A, with V_A set to dc voltage. Monitor circuit should be connected directly across CSP normally open contacts; **VOLTAGE, 1, DC, 125, ON, EXECUTE.**
2. Refer to KA-4 relay settings on CSP and ramp dc voltage until CSP contacts close. This dc voltage value should be within (±5%) of rated dc voltage.
3. Record the CSP minimum pickup value.
4. De-initiate V_A; **OFF, EXECUTE.**

CSG UNIT PICKUP TEST

1. Connect relay terminals 20(±) and 1(N) to V_A, with V_A set to dc voltage. Monitor circuit should be connected directly across CSP normally open contacts; **VOLTAGE, 1, DC, 125, ON, EXECUTE.**

2. Refer to KA-4 relay settings on CSG and ramp dc voltage until CSG contacts close. This dc voltage value should be within (±5%) of rated dc voltage.
3. Record the CSG minimum pickup value.
4. De-initiate V_A; **OFF, EXECUTE.**

SQUELCH UNIT PICKUP TEST

1. Connect relay terminals 4(±) and 3(N) to V_A, with V_A set to dc voltage. Monitor circuit should be connected directly across SQUELCH UNIT normally open contacts; **VOLTAGE, 1, DC, 125, ON, EXECUTE.**
2. Refer to KA-4 relay settings on SQUELCH UNIT and ramp dc voltage until SQUELCH UNIT contacts close. This dc voltage value should be within (±5%) of rated dc voltage.
3. Record the SQUELCH UNIT minimum pickup value.
4. De-initiate V_A; **OFF, EXECUTE.**

ZENER DIODE TEST

1. Connect relay terminals 9(±) and 8(N) to I_A.
2. Set I_A equal to 200mA and initiate I_A; **CURRENT, 1, AC, 0.2, ON, EXECUTE.**
3. Using an external voltmeter connected in parallel across relay terminal 8 and 9, the output voltage through the zener diode should not exceed 3.5 volts.
4. De-initiate I_A; **OFF, EXECUTE.**

RECEIVER UNIT TEST

1. Refer to I.L. 41-923.4M for detailed instructions.

Testing Westinghourse Type KC Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 50
Function: Instantaneous Overcurrent

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the KC-2 and KC-4 protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature — I.L.41-776.F

Test Equipment Instructional Material — PULSAR Operating Manual

Description of Relay

The KC relay is a non-directional current or fault detector which operates for all phase and ground faults to supervise the tripping of other relays. The KC relay is well suited to breaker failure relaying for indicating the presence or loss of current flow in the circuit breaker. The KC relay could be used in a single bus/single breaker, ring bus or breaker and one-half scheme.

The KC relays consist of either one or two phase instantaneous overcurrent units, one ground instantaneous unit and an indicating contactor switch. Each instantaneous overcurrent unit consists of an induction cylinder, capacitor, varistor and a transformer. The components are connected that a contact closing torque is produced when the current exceeds the specified tap value.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operating manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

SETUP AND PROCEDURE

For each test:

Assign current sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	5	4	I_A	0.5	0°	60.0
I_B	9	8	I_B	0.5	0°	60.0
I_C	7	6	I_C	0.5	0°	60.0
MON	10	1				

MINIMUM PICKUP TEST, TOP UNIT

1. Set I_A equal to tap value and initiate; **CURRENT, 1, AC, 0.5, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_A; **OFF, EXECUTE.**

MINIMUM PICKUP TEST, MIDDLE UNIT

1. Set I_B equal to tap value; **CURRENT, 2, AC, 0.5, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_B; **OFF, EXECUTE.**

MINIMUM PICKUP TEST, LOWER UNIT

1. Set I_C equal to tap value; **CURRENT, 3, AC, 0.5, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp current up or down to determine minimum pickup value.
3. Record the minimum pickup value.
4. De-initiate I_C; **OFF, EXECUTE.**

TIMING TEST

1. Repeat similar procedures for top unit, middle unit and bottom unit.
2. Move monitor circuit to timer stop gate.
3. Set I_A, I_B, I_C equal to fault current level(s) i. e., 2x tap and turn outputs off when relay trips; **CURRENT, 0, AC, 1.0, ON, SHIFT, A-OFF, ON, EXECUTE**. This command will set all 3 current channels simultaneously.
4. Initiate I_A, I_B, I_C independently using the following commands; **CURRENT, 1, ON, TIMER START, EXECUTE**. Repeat for CURRENT 2 and 3.
5. Repeat tests as necessary.
6. Reset A-OFF function; **SHIFT, A-OFF, OFF, EXECUTE.**

Testing Westinghouse KD Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 21
Function: Distance

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the KD-4, KD-10, KD-11 and KD-41 protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-490D & 41-491.4N
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The KD relay designed by Westinghouse Electric Corporation (ABB). The KD compensator relay is designed where a polyphase four-pole cylinder relay unit is used for the 3-phase and another polyphase unit is used for the phase-to-phase unit. This allows the KD relay 3-phase unit to respond to 3-phase faults and the phase-to-phase unit to respond to phase-to-phase faults. Between these two units, one or the other unit will respond to any double-phase-to-ground fault, regardless of which pair of phases is involved.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs OFF before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The type KD relay, is a polyphase compensator relay which provides a single zone of phase protection for all three phases.

Test Connections:

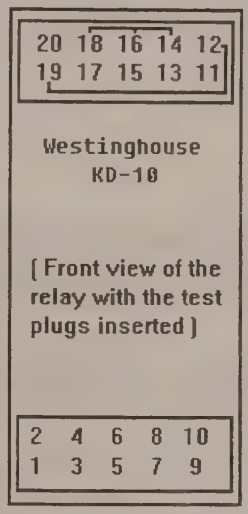
Potentials: 7,8,and 9

Currents: Jumper 12-19, 14-16-18, these jumpers will remain throughout all tests.

3-phase: potentials 7,8,9. Current in 13, out 18. Set the angles for the 3-phase MTA.

Phase-phase: A-B, 7,8,9. Current in 13, out 15 B-C, 8,9,7. Current in 15, out 17. C-A, 9,7,8. Current in 17, out 13. Set angles for phase-phase MTA.

Contacts: 3-phase, 10 and 20.
phase to phase, 10 and 11.



CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			o o→	o o→	o o→
	AMPS		AMPS		AMPS
	o o→		o o→		o o→

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table. The test values are based upon a 75° maximum torque angle setting and open delta voltages.

KD relay settings are; T=5.8, S=1, M=0, where;

$$Z = \frac{TS}{1 + M}$$

Jumper relay terminals 12 to 19 and 14 to 16 to 18. These terminals will remain jumpered throughout all testing of the KD relay.

Refer to I.L. and specific internal schematic on KD relay under test for appropriate monitoring circuit of 3Ø and Ø to Ø tests.

3-Phase Reach Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	8	V_A	30	0°	60.0
V_B	9		V_B	30	300°	60.0
I_A	13	18	I_A	5	105°	60.0
MON	*	*				

Reach Test

1. Connect monitor circuit to appropriate KD relay terminals.
2. Initiate voltage channels; **VOLTAGE, 1, AC, 30, ON, VOLTAGE, 2, AC, 30, PHASE, 300, ON, EXECUTE**.
3. Set I_A equal to a current value 0.05 amps less than the calculated value of I_F, based upon the formula;

$$I_F = \frac{V_F}{Z}$$

CURRENT, 1, PHASE, 105, AC, 5, ON, EXECUTE.

4. Using the Ramp Arrow keys ramp I_A up or down until the 3Ø contact operates.
5. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**
6. Leave voltage channels on.

Maximum Torque Angle Test

1. Set I_A equal to a current value 50% higher than the calculated value of I_F; **CURRENT, 1, AC, 7.5, PHASE, 105, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp I_A phase angle from 105° to ±30° to find θ_1 and θ_2 until the 3Ø contact operates.
3. Refer to the I.L. for determining the maximum torque angle.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, CURRENT, 1, OFF, EXECUTE.**

A-B Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	8	V_A	30	0°	60.0
V_B	9		V_B	105	278°	60.0
I_A	13	15	I_A	5	75°	60.0
MON	*	*				

Reach Test

1. Connect monitor circuit to appropriate KD relay terminals.
2. Initiate voltage channels; **VOLTAGE, 1, AC, 30, ON, VOLTAGE, 2, AC, 105, PHASE, 278, ON, EXECUTE.**
3. Set I_A equal to a current value 0.05 amps less than the calculated value of I_F, based upon the formula; V_F = 30 volts, the faulted phase, A-B.

$$I_F = \frac{V_F}{Z}$$

CURRENT, 1, PHASE, 75, AC, 5, ON, EXECUTE.

4. Using the Ramp Arrow keys ramp I_A up or down until the Ø - Ø contact operates.
5. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**
6. Leave voltage channels on.

Maximum Torque Angle Test

1. Set I_A equal to a current value 50% higher than the calculated value of I_F; **CURRENT, 1, AC, 7.5, PHASE, 75, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp I_A phase angle from 75° to ±30° to find θ_1 and θ_2 until the Ø-Ø contact operates.
3. Refer to the I.L. for determining the maximum torque angle.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, CURRENT, 1, OFF, EXECUTE**.

B-C Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	9	7	V_A	30	0°	60.0
V_B	8		V_B	105	278°	60.0
I_A	15	17	I_A	5	75°	60.0
MON	*	*				

Reach Test

1. Connect monitor circuit to appropriate KD relay terminals.
2. Initiate voltage channels; **VOLTAGE, 1, AC, 30, ON, VOLTAGE, 2, AC, 105, PHASE, 278, ON, EXECUTE.**
3. Set I_A equal to a current value 0.05 amps less than the calculated value of I_F, based upon the formula; V_F = 30 volts, the faulted phase, B-C.

$$I_F = \frac{V_F}{Z}$$

CURRENT, 1, PHASE, 75, AC, 5, ON, EXECUTE.

4. Using the Ramp Arrow keys ramp I_A up or down until the Ø-Ø contact operates.
5. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**
6. Leave voltage channels on.

Maximum Torque Angle Test

1. Set I_A equal to a current value 50% higher than the calculated value of I_F; **CURRENT, 1, AC, 7.5, PHASE, 75, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp I_A phase angle from 75° to ±30° to find θ_1 and θ_2 until the Ø-Ø contact operates.
3. Refer to the I.L. for determining the maximum torque angle.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, CURRENT, 1, OFF, EXECUTE.**

C-A Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	8	9	V_A	30	0°	60.0
V_B	7		V_B	105	278°	60.0
I_A	17	13	I_A	5	75°	60.0
MON	*	*				

Reach Test

1. Connect monitor circuit to appropriate KD relay terminals.
2. Initiate voltage channels; **VOLTAGE, 1, AC, 30, ON, VOLTAGE, 2, AC, 105, PHASE, 278, ON, EXECUTE.**
3. Set I_A equal to a current value 0.05 amps less than the calculated value of I_F, based upon the formula; V_F = 30 volts, the faulted phase, C-A.

$$I_F = \frac{V_F}{Z}$$

CURRENT, 1, PHASE, 75, AC, 5, ON, EXECUTE.

4. Using the Ramp Arrow keys ramp I_A up or down until the Ø-Ø contact operates.
5. De-initiate I_A; **CURRENT, 1, OFF, EXECUTE.**
6. Leave voltage channels on.

Maximum Torque Angle Test

1. Set I_A equal to a current value 50% higher than the calculated value of I_F; **CURRENT, 1, AC, 7.5, PHASE, 75, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp I_A phase angle from 75° to ±30° to find θ_1 and θ_2 until the Ø-Ø contact operates.
3. Refer to the I.L. for determining the maximum torque angle.
4. De-initiate PULSAR; **VOLTAGE, 1, 2, OFF, CURRENT, 1, OFF, EXECUTE.**

Testing General Electric Type IFCV Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 51
Function: Overcurrent with Voltage Restraint

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the IFCV protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-49946
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The IFCV is an overcurrent relay with voltage restraint. The IFCV is primarily used as system fault backup protection at the generator or source of fault current to minimize the damage resulting from a short circuit if the primary protective devices should fail to operate.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The IFCV is a single phase time over-current relay with voltage restraint.

Test Connections:

Current: 5 and 6
Potential: 7 and 8
Contacts: 1 and 2

General Electric IFCV
(Front view of the relay with the test plug inserted)

1	3	5	7	9
2	4	6	8	10

PULSAR

CONTROL MODULE	TIMER	VOLTS	VOLTS	VOLTS
		O O→	O O→	O O→
AMPS		AMPS		AMPS
O O→		O O→		O O→

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:

Assign current and voltage sources as indicated in the preset conditions table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	7	8	V_A	120	0°	60.0
I_A	5	6	I_A	2	0°	60.0
MON	1	2				

MINIMUM PICKUP TEST

1. Set V_A equal to restraint voltage and initiate V_A ; **VOLTAGE, 1, AC,120, ON, EXECUTE.**
2. Set I_A equal to tap value; **CURRENT, 1, AC, 2, ON, EXECUTE.** Note that disk should be slowly moving (creep).
3. Using the Ramp Arrow keys ramp I_A up and down to determine minimum pickup value.
4. Record the minimum pickup value.
5. De-initiate V_A and I_A; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE.**

TIMING TEST

1. Move monitor circuit to timer stop gate.
2. Set I_A equal to fault current level(s) i.e., 2x tap, and output to turn off when relay trips; **CURRENT, 1, AC, 4 , ON, SHIFT, A-OFF, ON, TIMER START, EXECUTE.**
3. Upon contact closure of IFCV contacts, record the timing value.
4. Repeat tests as necessary for other multiples of tap, for example;
   CURRENT, 1, AC, 6, ON, TIMER START, EXECUTE.
   CURRENT, 1, AC, 8, ON, TIMER START, EXECUTE.
   CURRENT, 1, AC, 10, ON, TIMER START, EXECUTE.

INSTANTANEOUS TEST

1. Move monitor circuit to terminals 1 and 3.

2. Set I_A equal to 20A ; **CURRENT, 1, AC, 20, SHIFT, A-OFF, ON, EXECUTE.**

3. Turn I_A ON; **CURRENT, 1, ON, EXECUTE**. Pulse I_A up or down until main trip contacts pickup, using the incremental steps of 1A and the **OFF, EXECUTE, ON, EXECUTE** sequential commands. When relay trips, output will automatically turn off.
4. Record pickup value.

Testing Westinghouse Type KLF Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: B
IEEE Device Number: 40
Function: Loss of Field

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the KLF protective relays acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	I.L. 41-748N
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The KLF relay is designed by Westinghouse Electric Corporation (ABB). The KLF is a single-phase relay connected to the ac side of asynchronous machine and contains three units connected so that the operation of two units sounds an alarm, warning of a low excitation condition. If the third unit operates the trip circuit is energized. The relay consists of two-air gaped compensators. two tapped auto transformers, one reactor, on cylinder type distance unit, directional unit with adjustable reactor, an under voltage unit with adjustable resistor, telephone relay and an indicating contactor switch.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the source output **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The KLF relay is a single phase relay connected to the ac side of a synchronous machine and contains three units.
Directional unit - top, Distance unit - middle, Undervoltage unit - bottom.

Test Connections:

Distance & undervoltage : Potentials 4 and 5, polarity on 5.

Current: 8 and 9, polarity on 9.

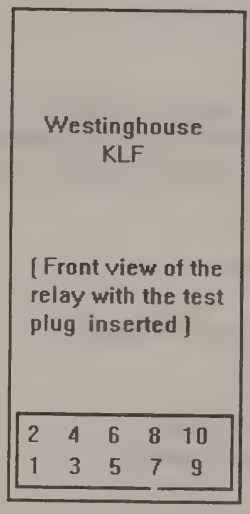
Directional: Potentials 6 and 7, polarity on 6.

Currents: 8 and 9, polarity on 9.

contacts: 1 and 10, with the middle unit closed.

Potential and current pickup values should be within + or - 3%.

Undervoltage: decrease voltage until the contacts close to the left.



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:
Assign current and voltage sources as indicated in the preset conditions table.

Make the following tap settings to the KLF relay:

$T_A = 11.5$ $T_C = 2.55$
$S_A = 2$ $S_C = 1$
$M_A = -.03$ $M_C = -.09$
T_C link in middle block should be set for $+T_C$ direction. This setting corresponds to a $Z_A = 23\ 7\Omega$ and $Z_C = 2.80\Omega$.

Distance Unit (Z) Pick-up Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	4	V_A	80	0°	60.0
I_A	9	8	I_A	2	90°	60.0
MON	10	1				

NOTE: Block Directional Contacts closed while testing Distance Unit.

1. Set VA for 80 volts and initiate; **VOLTAGE, 1, AC, 80, ON, EXECUTE.**
2. Set I_A for 2.0 amps and initiate; **CURRENT, 1, PHASE, 90, AC, 2, ON, EXECUTE.**
3. Using the Ramp Arrow keys and ramp the current up until the relay operates at approximately ±3% of 2.25 amps.
4. De-initiate PULSAR; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE.**

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	4	V_A	80	0°	60.0
I_A	9	8	I_A	9	270°	60.0
I_B	9	8	I_B	9	270°	60.0
MON	10	1				

NOTE: DUE TO BURDEN OF RELAY, I_A and I_B must be paralleled to do test.

1. Set VA for 80 volts and initiate; **VOLTAGE, 1, AC, 80, ON, EXECUTE.**
2. Set I_A and I_B for 9 amps and initiate; **CURRENT, 1, 2, PHASE, 270, AC, 9, ON, EXECUTE.**
3. Using the Ramp Arrow keys, ramp the current up or down until the relay operates at approximately ±3% of 19.0 amps.
4. De-initiate PULSAR; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE.**
5. Remove blocking material from Directional Unit.

Directional Unit (D) Pick-up Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	6	7	V_A	1	0°	60.0
I_A	9	8	I_A	5	347°	60.0
MON	10	1				

NOTE: Block Distance Unit contacts closed.

1. Set V_A to 1 volt and initiate; **VOLTAGE, 1, AC, 1, ON, EXECUTE.**
2. Set I_A phase angle to 347° and initiate, where current leads the voltage by 13°; **CURRENT, 1, AC, 5, PHASE, 347, ON, EXECUTE**. The relay contacts should be closed. This is the maximum torque angle position.
3. Raise the voltage of V_A to 120 volts; **VOLTAGE, 1, AC, 120, EXECUTE.** Using the following keystrokes; **CURRENT, 1, PHASE**, and using the

Ramp Arrow keys vary the phase angle of I_A where the moving contact makes contact with the left-hand contact. These two angles (where torque reverses) should be 77° and 257° current lagging the voltage or in reference to the I.L., 283° and 103° current leading the voltage, respectively. All phase angle accuracies should be within ±4°.

4. De-initiate voltage and current outputs; **VOLTAGE, 1, CURRENT, 1, OFF, EXECUTE**.
5. Remove blocking material from Distance Unit.

Undervoltage Circuit Test

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		Hz
	±	N			∠	
V_A	5	7	V_A	120	0°	60.0
MON	10	1				

NOTE: Block both Distance and Directional Unit contacts closed.

1. Set V_A for 120.0 volts; **VOLTAGE, 1, AC, 120, ON, EXECUTE.**
2. Using the Ramp Arrow keys ramp the voltage down until the relay operates at approximately ±3 volts of 80.0 volts.
3. De-initiate PULSAR; **VOLTAGE, 1, OFF, EXECUTE.**

Telephone Relay Pick-up Test

1. Apply rated dc volts across relay terminals 10 and 3; **VOLTAGE, 1, DC, 125, ON, EXECUTE.**
2. The telephone relay (X) should open its contact.
3. Manually close the distance unit (Z) contacts and the directional unit (D) contacts, with this simultaneous simulation the telephone relay (X) contacts should close.
4. De-initiate PULSAR; **VOLTAGE, 1, DC, 0, OFF, EXECUTE.**

Testing General Electric Type PJC Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 51
Function: Overcurrent Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the PJC protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-27893B
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The PJC32 relays are commonly used for instantaneous overcurrent protection of feeder circuits and for motors in conjunction with time-delay relays.

PRECAUTIONS

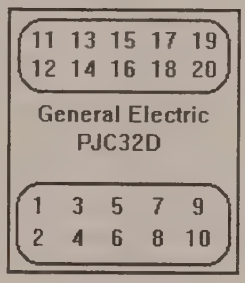
**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The PJC32 consists of three PJC units and is commonly used for instantaneous overcurrent protection of feeder circuits and for motors in conjunction with time delay relays.
Currents: 2 and 3, 5 and 6, 8 and 9.
Contacts: 1 to 12, 7 to 15, 10 to 18.



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O	O O	O O
	AMPS		AMPS		AMPS
	O O		O O		O O

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SET UP AND PROCEDURE

For each test:

Assign current sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
I_A	2	3	I_A	*	0°	60.0
I_B	5	6	I_B	*	0°	60.0
I_C	8	9	I_C	*	0°	60.0
MON	*	*				

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

PICKUP TEST

1. Connect the monitor circuit to the appropriate relay contacts.
2. Set I_A to the minimum pickup value using the following keystrokes; **CURRENT, 1, AC, (*), EXECUTE**.
3. Initiate the PULSAR; **CURRENT, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp I_A to find the pickup.
4. Record the pickup value, refer to the PJC32 I.L. for any adjustment.
5. Turn I_A OFF, whenever an adjustment is required or the test is completed. **CURRENT, 1, OFF, EXECUTE**.

TIMING TEST

1. Move the monitor circuit to timer stop gate, (T2).
2. Set I_A to the pickup value, using the following keystrokes; **CURRENT, 1, AC, (*), EXECUTE**.
3. Set the output to turn OFF when the relay trips, using the following keystrokes; **SHIFT, A-OFF, ON, EXECUTE**.
4. Initiate I_A and start the Timer using the following keystrokes; **ON, TIMER, START, EXECUTE**.
5. Record the timing pickup value. Repeat the test if necessary

6. Reset Auto-Off, using the following keystrokes;
SHIFT, A-OFF, OFF, EXECUTE.

Testing General Electric Type PJV Rely

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 29/59
Function: Under/over voltage Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the PJV protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEI-28802
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The PJV11L and PJV12B relays are single frequency AC or DC operated devices. These relays are single element high speed plunger type voltage relays.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The type PJV is a plunger relay designed for general service. This relay is a non-directional and instantaneous when in operation.
Single Phase relay:
Currents: 5 and 6,polarity on 5
contacts: 1 and 2

General Electric
PJV
[Front view of the relay with the test plug inserted]

1	3	5	7	9
2	4	6	8	10

PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SET UP AND PROCEDURE

For each test:
Assign voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	5	6	V_A	*	0°	60.0
						60.0
MON	1	2				

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

NOTE: If output voltage required exceeds 300 volts, see Operating Procedures, Section 1.3, Voltage Sources - Outputs Summed Together.

PICKUP TEST

1. Connect the monitor circuit to the appropriate relay contacts.
2. Set V_A to the expected pickup value using the following keystrokes; **VOLTAGE, 1, AC, (*), EXECUTE**. NOTE: If DC relay substitute "DC" for "AC".
3. Initiate the PULSAR; **VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys ▲,▼, ramp V_A to find the pickup.
4. Record the pickup value, refer to the PJV I.L. for any adjustment.
5. Turn V_A OFF, whenever an adjustment is required or the test is completed. **VOLTAGE, 1, OFF, EXECUTE**.

TIMING TEST

1. Move the monitor circuit to the timer stop gate, (T2).
2. Set V_A to the pickup value using the following keystrokes; **VOLTAGE, 1, AC, (*), EXECUTE**. NOTE: If DC relay, substitute "DC" for "AC".
3. Set the output to turn OFF when the relay trips using the following keystrokes; **SHIFT, A-OFF, ON, EXECUTE**.
4. Initiate V_A and start the Timer using the following keystrokes; **ON, TIMER, START, EXECUTE**.

5. Record the timing pickup value. Repeat the test if necessary.
6. Reset **A-OFF**, using the following keystrokes; **SHIFT, A-OFF, OFF, EXECUTE.**

Testing Basler Type PRS-170 Relay

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 25A
Function: Auto-Synchronizing Relay

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the Basler Model PRS-170 Auto-Synchronizing relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	A90 95100 990
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The PRS-170 is a auto-synchronizing relay, with add-on modules for voltage and speed control. The synchronizer will automatically adjust generator voltage and frequency until the generator and bus are within preselected values. Then if the voltages and slip frequency are within limits, it will automatically close the breaker.

PRECAUTIONS

*****************WARNING****************

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs <u>OFF</u> before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

The PRS-170 is an auto-sychronizing relay, with add-on modules for voltage and speed control. The synchronizer will automatically adjust generator voltage and frequency until the generator and bus are within limits, it will automatically close the breaker.

PRS-170 TERMINALS:

1 and 2 = 120v power source
3 and 4 = To Bus voltage
5 and 6 = To Generator voltage
11 and 12 = To Breaker close
13 and 14 = To Raise Speed
16 and 17 = To Lower Speed
19 and 20 = To Raise voltage
22 and 23 = To Lower voltage

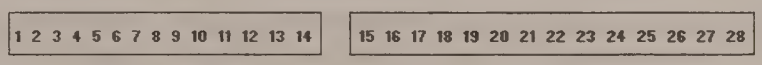
PULSAR TEST CONDITIONS						
Assign	Connect		Test	Values		Hz
	±	N			∡	
U_A	3	4	U_A	120°	0°	60.0
U_B	5	6	U_B	*	0°	60.0
MON	@	@				
U_A = Bus volts, U_B = Generator volts						

@ = Monitor connections vary for each individual test.

* = U_B amplitudes vary depending on the test.

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

PRS-170 REAR VIEW



Relay Notes:

For following tests, assign voltage sources as indicated in the preset conditions table below.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	3	4	V_A	120	0°	60.0
V_B	5	6	V_B	*	0°	60.0
MON	@	@				
V_A = BUS Voltage and V_B = GENERATOR Voltage						

(@) MONITOR connections vary for each individual test. See test procedure for connections. (*) V_B amplitudes vary depending on test.

NOTE: Apply AC logic voltage to relay terminals 1 and 2 for all tests.

LOW VOLTAGE PICKUP TEST (A1 OPTION ONLY)

1. Set V_A and V_B equal to rated voltage and turn on using the following keystrokes; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE**. Connect MONITOR leads to relay terminals 19 and 20.
2. Ramp V_B down using the appropriate ▼ RAMP key until the relay's LOW VOLTAGE LED lights and contacts pickup making the Timer MONITOR LED light. To ramp voltage down use the following keystrokes;

   VOLTAGE, 2, AC, and press the appropriate ▼ RAMP key.
3. Record the low voltage pickup value (adjustable between ± 0.5 to ± 4.5% difference between V_A and V_B).
4. Return V_B to rated voltage (use the ▲ RAMP key), and proceed to the next test.

   NOTE: For A2 option, undervoltage control, use same procedure except pickup value is a set voltage amplitude not a % difference.

HIGH VOLTAGE PICKUP TEST (A1 OPTION ONLY)

1. If V_A and V_B are not set from previous test, set V_A and V_B equal to rated voltage and turn on using the following keystrokes; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE**. Move MONITOR leads to relay terminals 22 and 23.

2. Ramp V_B up using the appropriate ▲ RAMP key until the relay's HIGH VOLTAGE LED lights and contacts pickup making the Timer MONITOR LED light. To ramp voltage up use the following keystrokes; **VOLTAGE, 2, AC**, and press the appropriate ▲ RAMP key.
3. Record the high voltage pickup value (adjustable between ± 0.5 to ± 4.5% difference between V_A and V_B).
4. Return V_B to rated voltage (use the ▼ RAMP key), and proceed to the next test.
NOTE: For A2 option, overvoltage control, use same procedure except pickup value is a set voltage amplitude not a % difference.

LOW FREQUENCY/HIGHER SPEED TEST (F1 OPTION ONLY)

1. Set V_A and V_B equal to rated voltage and turn on using the following keystrokes; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE**. Move MONITOR leads to relay terminals 13 and 14.
2. Ramp V_B frequency down using the appropriate ▼ RAMP key until the relay's LOW FREQUENCY LED lights and contacts pickup making the Timer MONITOR LED light. To ramp frequency down use the following keystrokes; **VOLTAGE, 2, FREQ**, and press the appropriate ▼ RAMP key.
3. Record the frequency pickup value and that the control contacts closed.
4. Return V_B to system frequency (use the ▲ RAMP key), and proceed to the next test.

HIGH FREQUENCY/LOWER SPEED TEST (F1 OPTION ONLY)

1. If V_A and V_B are not set from previous test, set V_A and V_B equal to rated voltage and turn on using the following keystrokes; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE**. Move MONITOR leads to relay terminals 16 and 17.
2. Ramp V_B frequency up using the appropriate ▲ RAMP key until the relay's HIGH FREQUENCY LED lights and contacts pickup making the Timer MONITOR LED light. To ramp frequency up use the following keystrokes; **VOLTAGE, 2, FREQ**, and press the appropriate ▲ RAMP key.
3. Record the frequency pickup value and that the control contacts closed.
4. Return V_B to rated frequency (use the ▼ RAMP key), and proceed to the next test.

SLIP FREQUENCY PICKUP TEST

1. If V_A and V_B are not set from previous test, set V_A and V_B equal to rated voltage and turn on using the following keystrokes; **VOLTAGE, 1, 2, AC, 120, ON, EXECUTE**. Move MONITOR leads to the "breaker close" relay terminals 11 and 12.
2. Ramp V_B frequency up using the appropriate ▲ RAMP key until the relay's SYNC LED lights and contacts pickup making the Timer MONITOR LED light. To ramp frequency up use the following keystrokes; **VOLTAGE, 2, FREQ**, and press the appropriate ▲ RAMP key. Wait an appropriate time (depending on slip frequency) between increments to allow the relay time to operate. Continue slowly incrementing frequency up until the SYNC and MONITOR LED's no longer light.
3. Record the maximum slip frequency pickup value as the last slip value where the relay would close every time.
4. Return V_B to rated frequency (use the ▼ RAMP key), and proceed to the next test.

ADVANCE TIMING TEST

1. Move monitor circuit to timer start gate, (T1).
2. Set V_A to rated voltage by using the following keystrokes; **VOLTAGE, 1, AC, 120, ON, EXECUTE**.
3. Set V_B to an appropriate output voltage and slip frequency, but do not turn on yet. For example use the following keystrokes to set a slip of 60.1 Hz; **VOLTAGE, 2, AC, 120, FREQ., 60.100, EXECUTE**. V_B DEGREES display should have dashed lines (the dashes will reset to zero's when the test is executed).
4. Set V_A and V_B to turn on and the Timer to Stop On Synchronization by using the following keystrokes, **VOLTAGE, 1, 2, Shift, TSOS, ON, EXECUTE**. V_B will turn on in phase with V_A, but will slip out of phase at the selected slip frequency. At the advance angle the relay contacts will close, thus starting the timer, when the two voltages slip into phase the Timer will stop and the outputs will turn off.
5. Read and record time. The time indicated should be the advance time setting of the relay.

Testing General Electric Type PVD

AVO
Multi-Amp

PULSAR

Date: September 30, 1993 Rev: A
IEEE Device Number: 87
Function: Transformer Differential

This relay test sheet describes the use of the AVO Multi-Amp PULSAR test instrument to perform the PVD protective relay acceptance tests. Test connections to the AVO Multi-Amp PULSAR relay test set and manufacturer recommended relay settings are included.

References:

Manufacturer's Reference Literature	GEK-45405B
Test Equipment Instructional Material	PULSAR Operating Manual

Description of Relay

The PVD21 relays are single phase, high speed, high impedance, voltage operated relays that are designed to provide protection in bus differential schemes when used in conjunction with suitable current transformers.

PRECAUTIONS

**********WARNING**********

Dangerous and potentially fatal voltage can be developed across the output terminals of the PULSAR relay test set, refer to the PULSAR operation manual for further instructions.

Always turn the outputs **OFF** before connecting, removing or touching any output terminal or test lead, use extreme caution when turning on or using the PULSAR relay test set.

ALWAYS TEST THIS RELAY IN ITS CASE.

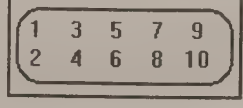
The Type PVD21 relays are single phase, high speed, high impedance, voltage operated relays that are designed to provide protection in bus differential schemes when used in conjunction with suitable current transformers.

Test Connections:

87H-Overcurrent, 3 and 4 polarity on 3.
Contact: 9 and 10.
87L-Voltage, 5 and 6 polarity on 6.
Contact: 1 and 2.

General Electric
PVD

(Front view of the relay with the test plug inserted.)



PULSAR

CONTROL MODULE		TIMER	VOLTS	VOLTS	VOLTS
			O O↴	O O↴	O O↴
	AMPS		AMPS		AMPS
	O O↴		O O↴		O O↴

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

Relay Notes:

SETUP AND PROCEDURE

For each test:
Assign current and voltage sources as indicated in the preset conditions table.

Execute the test as defined in the PULSAR CONDITIONS table.

PULSAR TEST CONDITIONS						
ASSIGN	CONNECT		TEST	VALUES		HZ
	±	N			∠	
V_A	6	5	V_A	*	0°	60.0
I_A	3	4	I_A	*	0°	60.0
MON	*	*				
V_A = 87L I_A = 87H						

ALWAYS REFER TO THE MANUFACTURERS' LITERATURE BEFORE TESTING!

PICKUP TEST-87H

NOTE: If output current required exceeds 30 Amperes, see Operating Procedures, Section 1.1, Current Sources - Parallel Operation.

1. Connect the monitor circuit to the appropriate relay contacts.
2. Set I_A to the minimum pickup value using the following keystrokes; **CURRENT, 1, AC, (*), EXECUTE**.
3. Initiate the PULSAR; **CURRENT, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys, ▲,▼, ramp I_A until the contacts pickup.
4. Record the pickup value, refer to the PVD21 I.L. for any adjustment.
5. Turn I_A OFF, whenever an adjustment is required or the test is completed. **CURRENT, 1, OFF, EXECUTE**.

PICKUP TEST-87L

NOTE: If output voltage required exceeds 300 volts, see Operating Procedure, Section 1.3, Voltage Sources - Outputs Summed Together.

1. Connect the monitor to the appropriate relay contacts.
2. Set V_A to the minimum pickup value using the following keystrokes; **VOLTAGE, 1, AC, (*), EXECUTE**.
3. Initiate the PULSAR; **VOLTAGE, 1, ON, EXECUTE**. Using the appropriate Ramp Arrow keys, ▲,▼, ramp V_A until the contacts pickup.

4. Record the pickup value, refer to the PVD21 I.L. for any adjustment.
5. Turn V_A OFF, whenever an adjustment is required or the test is completed. **VOLTAGE, 1, OFF, EXECUTE**.

Appendix A

Remote Operation Command Set:
PULSAR
Version 1.20

1. General

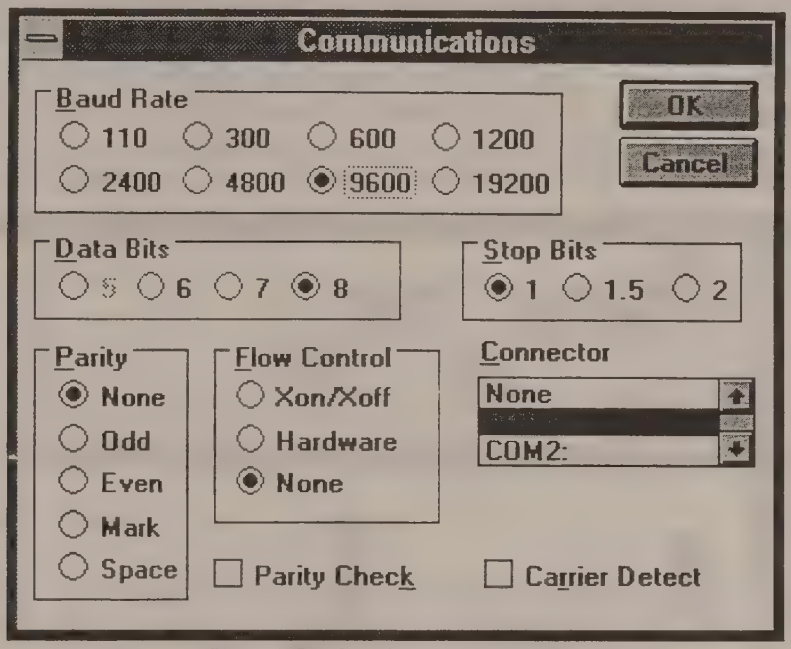


Figure 1. PULSAR Communication Setup

This document describes the command set for operating the PULSAR unit from an external controller. The following setup may be used to communicate with a PULSAR unit.

Baud Rate: 2400, 4800, 9600 or 19.2K.
Data Bits: 8.
Stop Bits: 1.
Parity: None.
Flow Control: None.
Connector: COM1, COM2 etc.
Parity Check: None.
Carrier Detect: None.

NOTE: It is recommended that the communication baud rate of 19.2K should be avoided. Because, at this baud rate occasional communication break down may occur.

2. OPTIONAL IEEE-488 GPIB Board Configuration

PULSAR uses National Instruments' PCII IEEE-488 GPIB Interface. The following sections describe the switches and proper configuration of the board.

See figure next page.

2.1. National GPIB PCII Card Configuration

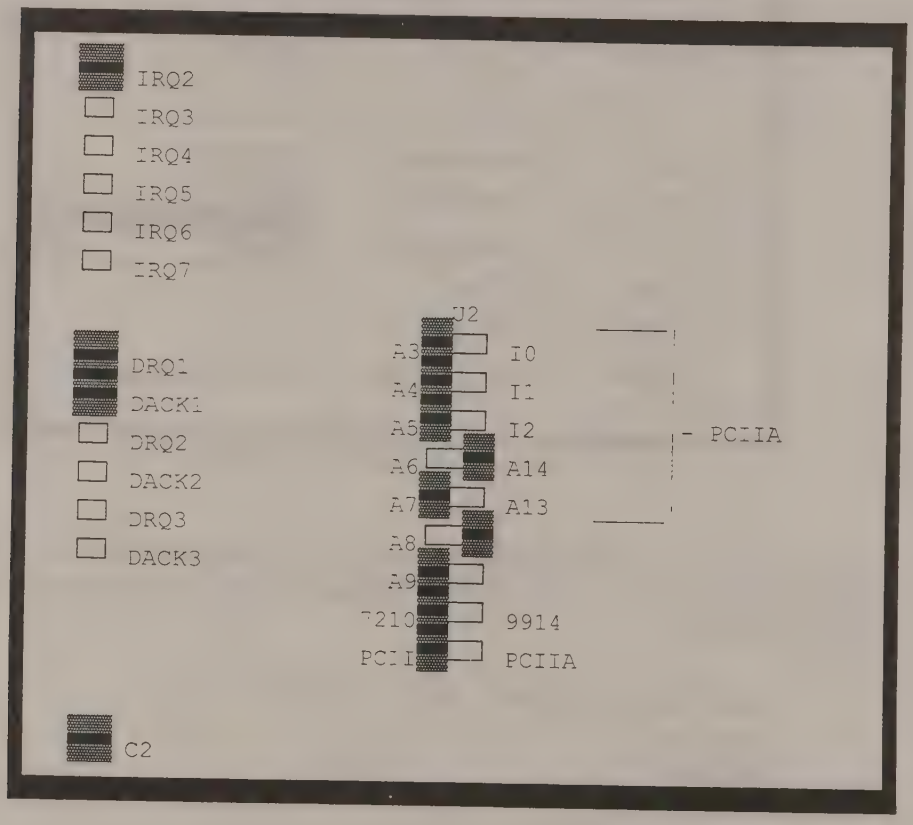
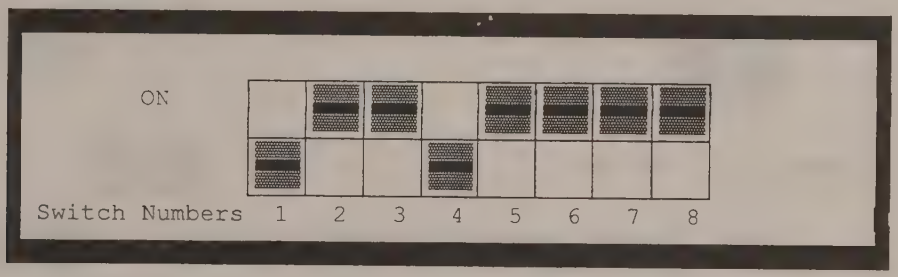


Figure above shows the default GPIB switch settings for the National Instruments PCII card which may be installed in the expansion slot of the PULSAR unit. The shaded area indicate the position of the jumper or switch on the GPIB card.

If you choose to order the GPIB card from National Instruments, order the PCII configuration, with the IRQ2 jumper selected.

2.2. PULSAR System Controller Switch (SW2)

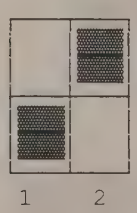
The following diagram exhibits the default switch setting for configuring the PULSAR System Controller module. PULSAR is configured for 9600 baud, (Note: PULSAR is always configured for 8 data bits, 1 stop bit, and no parity), 60 Hertz for domestic, or 50 Hertz for international, and the GPIB address is set to 1, even if a GPIB card is not present. The shaded areas of the diagram indicate the switch settings.



Switches 1 and 2

Switches 1 and 2 are used to select the RS232 rate for transferring data to PULSAR. The setting in the example above sets the data rate to 9600 baud. The other selections are as follows:

Switch setting for 19.2kb. This setting can only be used for the consecutive transfer of data in increments of less than 4k bytes without the delay of approximately 2 seconds before sending another consecutive data transfer.



Switch setting for 9600 baud.

ON

1 2

Switch setting for 4800 baud.

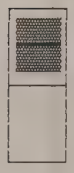
ON

Switch setting for 2400 baud.

Switch 3

Switch 3 is used to select the default frequency of the PULSAR unit.

ON



3

Switch setting for 60Hz.

ON

3

Switch setting for 50Hz.

Switches 4 through 7

ON

4 5 6 7

Switch setting for No GPIB communications.

ON

Switch setting for GPIB address 1.

ON

Switch setting for GPIB address 2.

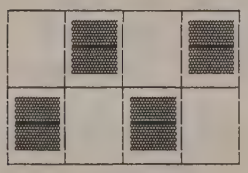
ON

Switch setting for GPIB address 3.

ON

Switch setting for GPIB address 4.

ON



Switch setting for GPIB address 5.

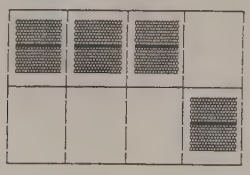
ON

Switch setting for GPIB address 6.

ON

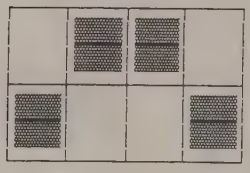
Switch setting for GPIB address 7.

ON



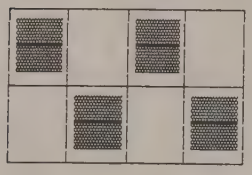
Switch setting for GPIB address 8.

ON



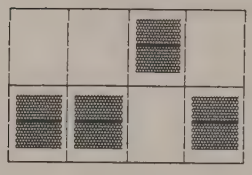
Switch setting for GPIB address 9.

ON



Switch setting for GPIB address 10.

ON

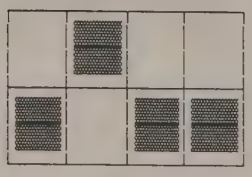


Switch setting for GPIB address 11.

ON

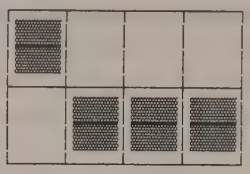
Switch setting for GPIB address 12.

ON



Switch setting for GPIB address 13.

ON



Switch setting for GPIB address 14.

ON

Switch setting for GPIB address 15.

Switch 8 is unused.

3. Definition

3.1. Syntax Diagram

A syntax diagram is a diagram that is used to explain the correct sequence and content for sending commands to the PULSAR unit. Such diagrams contain boxes, lines, characters, and sometimes arrows.

Horizontal lines without an arrow pointing right that connect boxes (or that connect other lines which eventually connect boxes) indicate logic flow from left to right. Presence of an arrow pointing left indicates logic flow opposite to the default direction.

If a vertical line connects to a line with a left arrow, that vertical line indicates a permissible logic choice only in the direction of that arrow. Other vertical lines that have multiple choices toward the right indicate that each of the choices to the right is logically permissible.

3.2. Command Constants

Remotely transmitted command constants consist of characters that appear in boxes within syntax diagrams as well as the space delimiter, and while the boxes never employ words with lower case letters for command constants (because lower case words are exclusively used for variables within boxes), ***lower case letters are allowed for input***. Command constant characters are capital letters, slashes, hyphens, and delimiters (comma, semicolon, space, and colon). The

following exceptions limit the general rule that command constants must be transmitted exactly as they appear in the boxes.

(1) The underline symbol is never transmitted.

(2) Non-underlined capital letters, slashes, or hyphens (i. e., all non-underlined characters except delimiters) are optional, but if at least one of these optional characters is transmitted, a single space must be transmitted after all optional characters in a box have been transmitted.

(3) Most transmitted misspellings are accepted for optional text in a box, but if a misspelled option begins with a valid choice of a required (i. e., underlined) starting character in a subsequent box, the logic will usually assume that the subsequent box is desired, so that a syntax error will be assumed if the remainder of the command is not fully valid. In practical terms, this means that in the unlikely case of a syntax error due to a misspelling in optional text, correct the spelling.

(4) If only underlined capital letters, slashes, and hyphens are transmitted for characters in a box, the transmission of a single space after them is optional.

(5) Lower case letters may be used instead of capital letters for input.

(6) Carriage return and line feed input characters are discarded as they are received.

3.3. Command Variables

A command variable is a set of lower case letters that occurs within a box in a syntax diagram. The form and function of each command variable is defined in each command.

3.4. Terminator

A terminator is a delimiter that is permitted to be the final character of a PULSAR command. The two valid terminators are semicolon and comma whose use is defined as follows.

Commands ending with a comma are stored until a command ending with semicolon is received. This eliminates the effect of a communication delay between each pair of commands in a lengthy string of commands, so that all commands between semicolons will be executed nearly simultaneously.

A command (or string of commands separated by commas) which ends with a semicolon terminator will be executed as soon as it can be processed.

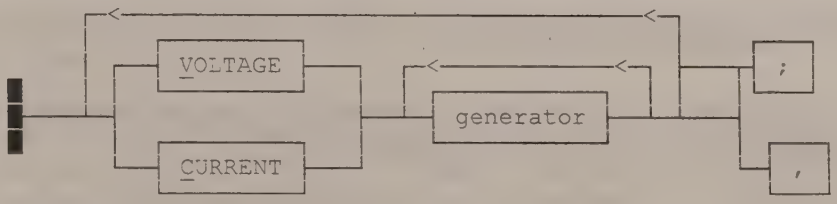
3.5. Multiple Choice Beginning Symbol

The vertical symbol below is the multiple choice beginning symbol. This shows the starting point for the diagrammed syntax of a command which has more than one choice for a starting command constant.

4. Commands

4.1. Generator Selection Command

This command selects a group of current and/or voltage generators which will be acted on by subsequent Generator Control Commands (see section 4.2) and Waveform Commands (see section 4.3). This selection remains in effect until the next selection or a Unit Reset Command (see section 4.8).



where:

V - indicates that a **voltage** generator is being selected.

C - indicates that a **current** generator is being selected.

generator - a single digit in the range of 0 to 9 indicating the **generator** to be included in this selection.

NOTE: Generator 0 is pre-defined to mean all generators of the same type i.e., V0 selects all voltage generators.

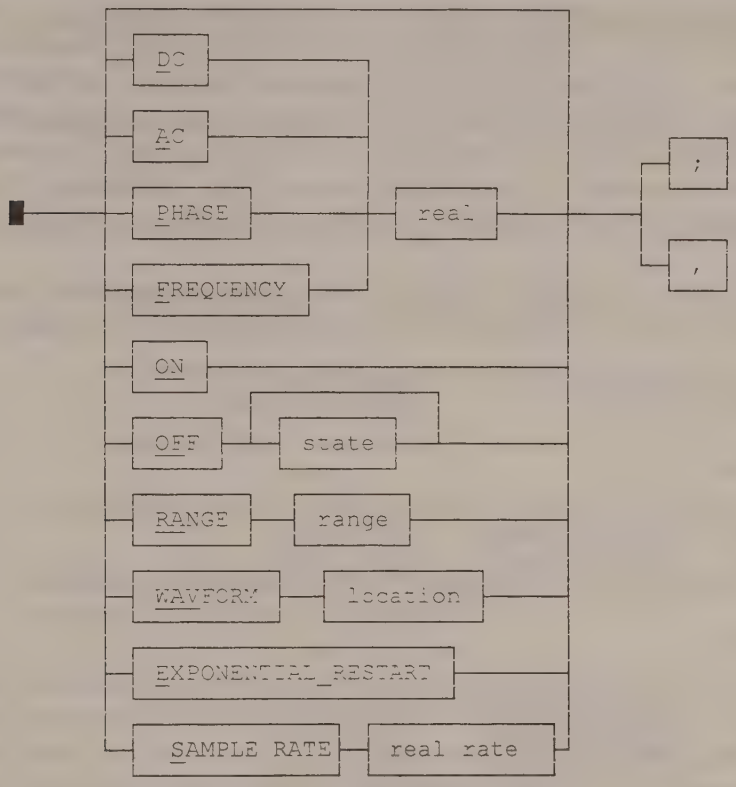
NOTE: All voltage generators may be freely moved among the slots of the PULSAR unit without manually adjusting anything in these generators, but it is hazardous to do this while the power is on. The PULSAR unit assigns numbers to the voltage generators according to their slot position as follows. The left-most voltage generator is voltage generator number 1, the nearest voltage generator to the right of voltage generator number 1 is voltage generator number 2, the nearest voltage generator to the right of voltage generator number 2 is voltage generator number 3, etc. Everything stated above about voltage generators is independently true for current generators, so that if there is at least one of each type installed, there is both a voltage generator number 1 and a current generator number 1. The left-most generator will either be voltage generator 1 or current generator 1. Voltage and current generators may be interspersed among each other. There may be one or more empty slots between two filled generator slots. **The bottom right-most slot is the only one that is not permitted to be empty, and the generator that fills it is called the master generator.**

Example:

V1C2V3; = select voltage generators 1 and 3 and current generator 2. This could have been entered with V13C2;.

4.2. Generator Control Command

This command is used to specify the settings of the selected generators (see the Generator Selection Command, section 4.1).



where:

D - indicates that the **DC** amplitude offset voltage or current of the selected generators is to be set (in Volts or Amps).

A - indicates that the **AC** amplitude of the selected generator(s) is to be set (in Volts or Amps RMS).

P - indicates that the **phase** of the selected generator(s) is to be set (in degrees). The input real number range includes negative phase angles, but the PULSAR unit will display the input number in the range 0 to 359.9 degrees.

F - indicates that the **frequency** of the selected generator(s) is to be set in Hertz. Whenever the frequency is changed, that generator will be out of phase until all the generators are shut off or until the Restore Phase Command is executed (see section 4.10). When the frequency is

changed, the phase displayed on the altered generators will be replaced with dashes. When the system is placed in synchronization phase ref mode or self-zero mode the phase reference generator cannot be set below 1 hertz (see section 4.6). A lower frequency would prevent zero crossings from occurring, and cause system lockup. An entry of frequency zero (F0;) is not the same as DC. If DC without an offset is desired, enter A0; and a DC command (D2;) to a selected generator.

real - indicates the value of the amplitude, phase, or frequency expressed as a **real** number in decimal form. Allowed values for this variable are:

VARIABLE	RANGE	RESOLUTION
AC Voltage		
range 300	0 to 300 V RMS	.02 V RMS
range 30	0 to 30 V RMS	.002 V RMS
AC Current		
range 30	0 to 30 A RMS	.02 A RMS
range 15	0 to 15 A RMS	.02 A RMS
range 3	0 to 3 A RMS	.002 A RMS
DC Voltage		
range 300	-300 to +300 V	.04 V
range 30	-30 to +30 V	.004 V
DC Current		
range 30	-30 to +30 A	.04 A
range 15	-15 to +15 A	.04 A
range 3	-3 to +3 A	.004 A
Phase	0 to 359.9	.1
Frequency	0 to 20000 Hertz	.00005 Hertz

ON - indicates that the generator output of the selected generators should be turned **on.**

OF - indicates that the generator output of the selected generators should be turned **off**.

state - indicates the off **state** designated by a single digit among the following:

1. generator off, low impedance. (default for voltage generators).

2. generator off, high impedance. (default for current generators).

3. generator on, output zero.

If no state is specified, the generator is set to the default off state.

RA - indicates that the generator **Range** is to be set for the selected voltage and/or current generators.

range - indicates the generator **range number** which is the maximum number desired in volts or amps, not to exceed 300 in volts or 30 in amps; The PULSAR unit will choose the lowest range which contains the input value. For example, if an input of 150 is given for a voltage generator range, the 300 volt range will be selected by the PULSAR unit. Range of zero selects AUTO RANGE mode. In this mode, the lowest range for the current AC or DC amplitude setting will be chosen.

0 Automatic ranging (autoranging).

High range:

300 Voltage generator: 300 Volt.
30 Current generator: 30 Amp.

Mid range:

15 Current generator: 15 Amp.

Low range:

30 Voltage generator: 30 Volt.
3 Current generator: 3 Amp.

NOTE: If the user desires to send commands for an upward ramp of voltage or current for a generator (i.e., for a sequence of increasing Amplitude Commands for that generator), if the ramp starts within one range and eventually increases to a higher range, the user must first send a Range Command with the highest range sought in the entire upward ramp. If this is not done and the ramp begins in one range (for voltage or current), as soon as an Amplitude Command is sent for a higher range, a syntax error will result. If automatic ranging is selected, ramping does not generate a syntax error when the amplitude increases to high range.

WAV - indicates that the previously defined **Waveform** command is to be selected.

location - indicates the storage **location** to use. This must be "1" thru "16". Each generator contains up to 16 locations to use, depending on the available memory. Choose 1 thru 16 to indicate which waveform to use (as defined by the waveform command, see section 4.3). Choose 0 to select a data playback waveform (see section 4.3).

E - indicates that this is a **Exponential Restart** command. Upon execution of this command the DC offset exponent decay that was defined in the last waveform command is executed (see section 4.3).

Example:

F15000,P90, = set the previously selected generator(s) to 15kHz and 90 degrees (90 degrees lagging). This will be displayed as 90 degrees.

SA - indicates the rate at which the selected waveform is output. When the sample rate is changed, that generator may be out of

sync with the output of the other generators. The restore phase command should then be used to synchronously restart the output of the generators. The phase display on the altered generator will be replaced with dashes. Also, the sample command turns the generators zero degree pulse off, which when applied to the master generator, also disables its synch. phase ref. clock. If the unit is set for sync phase ref mode then all synchronous command execution will stop until the unit is set to another mode.

real rate - indicates a value from 0 to 20,000hz with .00005 resolution. A single period waveform filling a 4096 sample block running under a 20Khz sample clock would create about a 4.88hz waveform.

4.3. Generator Waveform Command

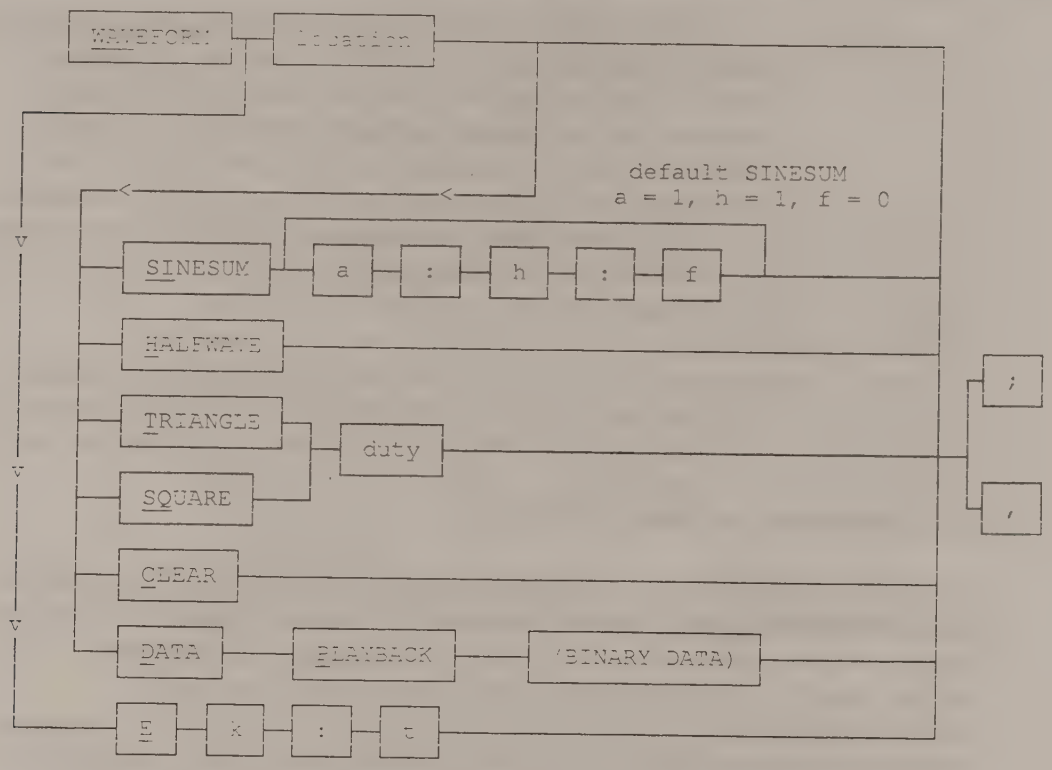
This command defines the type of waveform and the DC offset exponential decay for the previously selected generator(s). Allowed waveforms are square wave, triangle wave, half-wave sinewaves, and analytical sinewaves. The default sinewave is a full harmonic sinewave with no phase shift.

Analytical waveforms allow the user to create waveforms with a selectable content. The following function describes the analytical waveform:

$$a_1\sin(h_1 2\pi ft+\phi_1)+a_2\sin(h_2 2\pi ft+\phi_2)+a_3\sin(h_3 2\pi ft+\phi_3)+\ldots$$

where f is the frequency defined in the Generator Control Command (see section 4.2).

The DC offset exponential decay modifies the defined waveform by adding an exponentially decaying DC offset in the form $ke^{-\tau t}$.



where:

WAV - indicates that this is a **Waveform** command.

location - indicates the storage **location** to define. This must be "1" to "16". Each generator, depending on the memory configuration, contains up to sixteen waveform storage memories which can be independently defined. Choose 1 thru 16 to indicate which location to define. When used with Data-Playback, 1 thru 16 indicates a 4096 word waveform. "0" is only used with Data-Playback and indicates a 65536 word waveform.

SI - indicates that a **Sinusoidal** analytical waveform is to be summed into the existing waveform in the specified location.

a - indicates the **amplitude** of the harmonic as a fraction of the amplitude set in the Generator Control Command, section 4.2 (a real number in

decimal form, in the range of 0 to 1). A non zero positive number not equal to zero.

NOTE: Each amplitude specification in the analytical specification is defined as fractions (in the range of 0 to 1) of the amplitude set in the Generator Control Command. The vector sum of each component at the waveforms' maximum point must not exceed 1.0. (Note that the same harmonic can be sent more than once, adding new data to the waveform each time, while adding to that harmonic as a vector (adding 180 degrees out of phase is subtracting)).

h - indicates the **harmonic** of the frequency set in the Generator Control Command (an integer in the range of 1 to 50).

ϕ - indicates the **phase** of the harmonic (a real number in the range of -999.9 to +999.9).

H - indicates a **half-wave** sinewave.

T - indicates a **triangular** waveform.

SQ - indicates a **square** waveform.

duty - indicates the **duty cycle** of the triangle and square waves (real number in decimal form, 0 to 100 percent).

C - indicates that the selected location should be **cleared**. This should be done before defining a new waveform.

E - indicates that **exponential** parameters follow.

k - indicates the DC offset as a fraction of the exponent at time zero; a real number in the range -FS to +FS of current range.

NOTE: Does not cause auto ranging.

WARNING: Do not change range while exponent is in effect.

Example 1:
The following is a MACRO example of how a complex waveform is created using PulseMaster and a PULSAR. The desired waveform is 120 VAC consisting of 40% fundamental, 30% third harmonic, 20% fifth harmonic and 10% seventh harmonic, see result test waveform in figure below.

```
pxlatoff=1
>"v2, wav1c;"
>"v2, a120, wav1si .4:1:0:, wav1si .3:3:0, wav1si .2:5:0:0, wav1si .1:7:0;"
>"v2,on;"
plxatoff=0
```

Explanation:

pxlatoff=1
Turns off the translator that converts MACSART (EPOCH) commands to PULSAR commands. PULSAR commands are now sent directly.

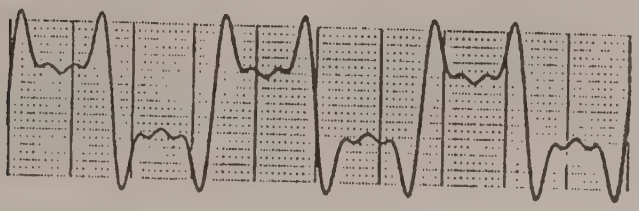
>"v2,wav1c;"
This clears wave location #1 on voltage channel #2.

>"v2, a120, wav1si .4:1:0, wav1si .3:3:0, wav1si .2:5:0, wav1si .1:7:0;"
Sets the amplitude to 120 volts and builds the waveform at wave location #1.

>"v2,on;"
Turns the output on.

pxlatoff=0
Turns the translator back on.

NOTE: '>' precedes a command in quotes to be sent to the PULSAR.
';' executes all commands sent to a PULSAR.



Complex Voltage Waveforms

Example 2:

The following is a MACRO example showing the use of the exponential decay feature of the PULSAR. The example shows a waveform consisting of 10 vac with a 15 vdc offset decaying over 100 milliseconds, see resultant waveform in figure below.

```
pxlatoff=1
>"v2,a10,on,wavE15:100,E;"
pxlatoff=0
```

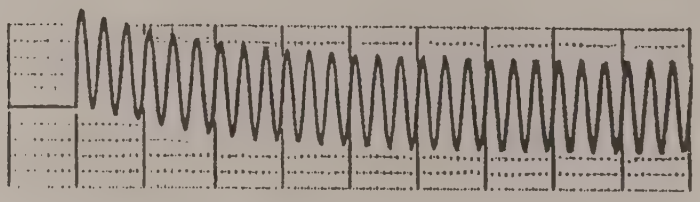
Explanation:

pxlatoff=1
Turns off the translator that converts MACSART (EPOCH) commands to PULSAR commands. PULSAR commands are now sent directly.

>"v2,a10,on,wavE15:100,E;"
Sets voltage channel #2 to 10 vac, adds 15 vdc to exponentially decay in 100 milliseconds and sends the exponential restart command.

pxlatoff=0
Turns the translator back on.

NOTE": 'v' precedes a command in quotes to be sent to the PULSAR.
';' executes all commands sent to a PULSAR.
'E' exponential restart is necessary to initiate the exponential decay.



DC Offset With Exponential Decay

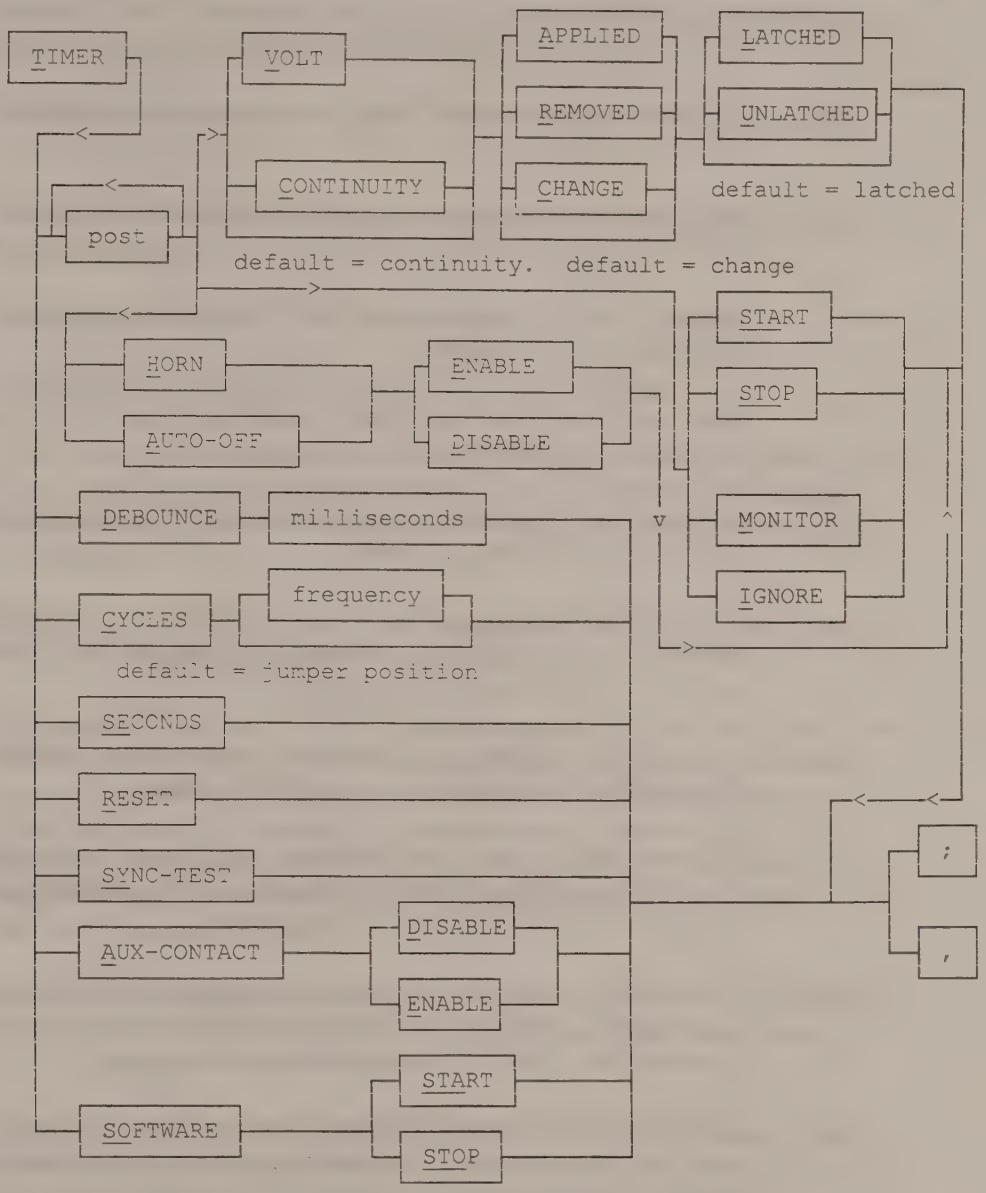
τ - indicates the **Time Constant** of the exponential decay in milliseconds. A real number in the range of 1 to 10,000.

D - indicates Data Playback

(BINARY DATA)- indicates binary data in INTEL HEX format (comtrade binary). This data is 4096 words (16 bits) in length or 65536 words in length.

4.4. Timer Control Command

This command controls the optional timer. If this module is not present then the commands are not available.



where:

T - indicates that this is the **timer** control command.

post - a single digit in the range of 0 to 3 indicating the timer **input binding post** number addressed by this command.

NOTE: Post 0 is pre-defined to mean all posts, i.e., posts 1, 2, and 3.

V - indicates that the selected input binding post(s) are placed in the **volt** mode.

C - indicates that the selected input binding post(s) are placed in the **continuity** mode. In this mode the post(s) are subject to continuity only.

A - indicates that the selected input binding post(s) are to be active when the input entity is **applied**.

R - indicates that the selected input binding post(s) are to be active when the input entity is **removed**.

C - indicates that the selected input binding post(s) are to be active when the input entity **changes state**.

L - indicates that activity on the selected input binding post(s) is to be **latched**, i.e., activity beyond the initial activity will be ignored, unless this command is resubmitted to the timer.

U - indicates that activity on the selected input binding post(s) is to be **unlatched**, i.e., changes of state affect the post(s).

HE - indicates that the timer **horn enable** mode is set for the specified binding post. When voltage or current is applied on the selected post the timer horn will sound until the activity is removed.

HD - indicates that the timer **horn disable** mode is set for the specified binding post. When valid activity occurs that would cause the timer horn to sound, the timer horn will remain off in this mode.

AE - indicates that the **auto-off** mode is set, and that valid activity on the specified binding post will cause the outputs of all generators to be placed in their respective off states. This holds true for the stop gate only.

AD - indicates that the **auto-off** mode is reset, and that valid activity on the specified binding post will not cause the outputs of all generators to be

placed in their respective off states. The generators must be turned off via the off command (see section 4.2).

STA - indicates that the **timer will start**, when valid activity on the specified binding post occurs.

STO - indicates that the **timer will stop**, when valid activity on the specified binding post occurs.

M - **monitoring** operation to be announced.

I - indicates that input binding post activity will be **ignored**.

D - indicates the **debounce time** to all input binding posts. An uninterrupted signal must be present for the specified time duration for the signal to become true. The maximum debounce time is 1.6383 seconds (1638.3 milliseconds).

milliseconds - is the debounce time in **milliseconds**. It is a decimal number with a resolution of 0.1 milliseconds.

CY - indicates that the output of the timer is in **cycles**, so that the timer's time is measured by the number of elapsed cycles. I.e., a multiplication of time and frequency. The period will be known from the frequency parameter which is required in this command. If no frequency is specified, the previous specified frequency is used. If no frequency is specified and no frequency was previously specified, the jumper selected frequency is used.

frequency - is the **frequency** in hertz, a decimal number. See the Generator Control Command (section 4.2) for the frequency range and resolution (integer 1-20,000).

SE - means that the time that is output by the timer is in **seconds**. The maximum range in seconds is 107374.1824.

R - indicates that the timer's time is **reset** to zero and all input binding posts are initialized to their most recent initial setting. For post with are change of states, the current state becomes the mutual state.

SY - indicates that the timer is started on a contact closure, and stopped when the two selected generators are **synchronized**. At the end of the test, the generator outputs will be in their off state, and the timer's display will show the sync time to within 100 microseconds. While the sync test is running no other commands can be sent.

AD - **disables** the auxiliary contact.

AE - **enables** the auxiliary contact.

SO - indicates that the timer start or stop is to be controlled via **software**.

STA - **start** the timer via software if preceded by an SO command, otherwise start the timer based on post configuration.

STO - **stop** the timer via software if preceded by an SO command, otherwise stop the timer based on post configuration.

Example (two commands):

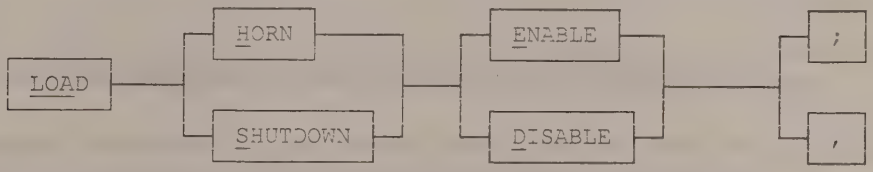
T 1 VRU, T 1 STO; = stop the timer when voltage is removed from the front panel unlatched binding post 1.

Example (multiple commands):

T 1 VAL, T 2 VRU; T 1 STA, T 2 STO; = The timer will begin timing when an voltage is applied to latched front panel binding post 1. Since the start condition is latched, it will continue timing without regard to the state of post 1. The timer will stop when a voltage is removed from post 2. Since post 2 is unlatched, the timer will resume timing if a voltage is applied to post 2.

4.5. Load Error Action Command

This command allows the user to specify the PULSAR's reaction to a generator load error.



where:

LOA - indicates the **load** command.

H - indicates whether the **horn** will sound when a generator load error occurs.

S - indicates whether the generator is to be **shut down** when encountering a load error.

E - indicates that the type activity is **enabled**.

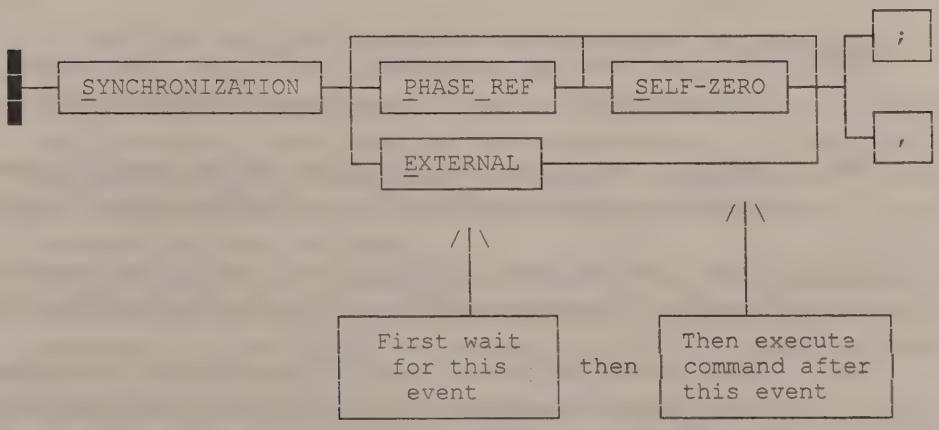
D - indicates that the type activity is **disabled**.

Example:

LHE; = enable horn to sound when a generator load error occurs, and the selected generator's display will flash.

4.6. Synchronization Command

This command specifies when the command is to be executed.



where:

S - indicates that this is the start of a **synchronization** command.

SP - indicates that execution of subsequent commands will be synchronized by the master generator's phase reference clock. The generator located in the bottom right-most slot is the master generator. In this mode, the PULSAR unit's command synchronization is controlled by the synch pulses generated as the master generators phase angle clock passes through zero degrees. If the master generator does not exist then the unit will switch to synch immediate mode. This is the default synch selection after power on and is not affected by the generators phase angle but is affected by its frequency. If the master generator is running under the Sample Rate command then the phase angle clock will be disabled and SP will not work.

NOTE: This command goes into affect as soon as the next comma or semicolon is received, it does not wait for a command synchronization signal.

SS - indicates that subsequent commands will be executed synchronous with each generator's own positive going zero crossing of the AC signal (**self zero crossing**). See note below.

NOTE: This command goes into affect as soon as the next comma or semicolon is received, it does not wait for a command synchronization signal.

S; - indicates that subsequent commands will be executed immediately in synch immediate mode where the synchronization signal is the wait timer's 50us clock.

NOTE: This command goes into affect as soon as the next comma or semicolon is received, it does not wait for a command synchronization signal.

SPS - indicates that subsequent commands will be executed at the first zero crossing after the master generator's phase reference passes through zero degrees.

NOTE: This command goes into affect as soon as the next comma or semicolon is received, it does not wait for a command synchronization signal.

SE - indicates that the sync pulse will be generated by an external source connected to the back of the system. This is provided to allow the adding of generator modules to the system.

NOTE: This command goes into affect as soon as the next comma or semicolon is received, it does not wait for a command synchronization signal.

WARNING: If the user switches from synch external to another synch mode before the synch pulses necessary to execute the semicolons and wait cycle commands loaded in the system have been received, then command execution will forever be behind the same number of synchronized events that were outstanding when the external mode was left.

Example: The following commands are sent with nothing connected to the external synch inputs

SE,v0,a1;a2;SI,a3;a4;SP,a5;a6;

The voltage generators will go to 1 volt as soon as the semicolon sent with a3 is received, to 2 volts as soon as the semicolon from a4 is received, to 3 volts upon receiving a synch pulse from the master generator after the semicolon for a5 is received and to 4 volts upon receiving a synch pulse from the master generator after the semicolon for a6 is received. The commands for a5 and a6 will remain loaded until the next synch event is received or the PULSAR unit is reset.

NOTE: The synchronization source (immediate, phase ref, external) cannot be changed while wait cycle timing events are going on (Ex. waic10;).

Example:

SP; execute commands at the left-most generator's phase reference.

NOTE: Sometimes the synchronization mode in use can produce some unexpected results especially when using self zero synchronization. For example the command string: "v0c0,s;p0;ss;a1,v1,p0,v2,p120,v3,p240,v0,on;" will cause all generators to come on at the same time at the prescribed phase angles. Whereas, the command string "v0c0,s;p0;ss;v1,p0,v2,p120,v3,p240;v0c0,a1,v0,on;" will cause each voltage generator to come on 120 degrees apart starting with the first generator that generates a positive going zero crossing once the last sequence is received.

In the first command string the on command is executed at the same time because each generators phase angle is set to zero when the last command

sequence is executed. In the second command string the phase angles are set first and then the on command sequence is executed by each voltage generator once the semicolon has been received and that generator produces a positive going zero crossing. Some other unexpected results are encountered when the restore phase command is used in synch self zero modes. When self zero synchronization is active and a generator is sent the restore phase command, the generators phase reference is reset on the next positive going zero crossing. If the generators phase angle is not zero or the current waveform has positive going zero crossings that do not occur at zero degrees then the generators phase reference will be shifted by the restore phase command. The restore phase command may also produce unexpected results in synch phase ref. mode and synch immediate when applied to the master generator. In synch phase ref. mode if the command "v0c0,wai2,re;" is issued then each generators phase reference will be shifted 2 msec and subsequent command synchronization will also be shifted 2msec.

4.6.1. LINE SYNCHRONIZATION

Pulsar was designed to be completely independent of the line voltage and frequency. However, there may be applications where synchronizing to the line frequency may be desirable. With Line Synchronization activated, the output voltages and currents will be in phase with the input power line (± 2 degrees) if the phase setting on the Pulsar outputs is zero degrees.

NOTE: Output settings other than 0 degrees will **Lag** the input power line by the value displayed on the channel. The outputs will stay synchronized as long as the line frequency does not change more than ± 1 Hertz.

where:

LSI; - command used to switch unit to Line Synchronous Mode.

NOTE: After switching to Line Synchronous Mode, allow a couple of minutes for the Pulsar to synchronize to the line. The frequency display on each output module will change from 60.000 (or 50.000) Hertz (indicating internal sync mode) to 60 (or 50) Hertz (indicating line sync mode) .

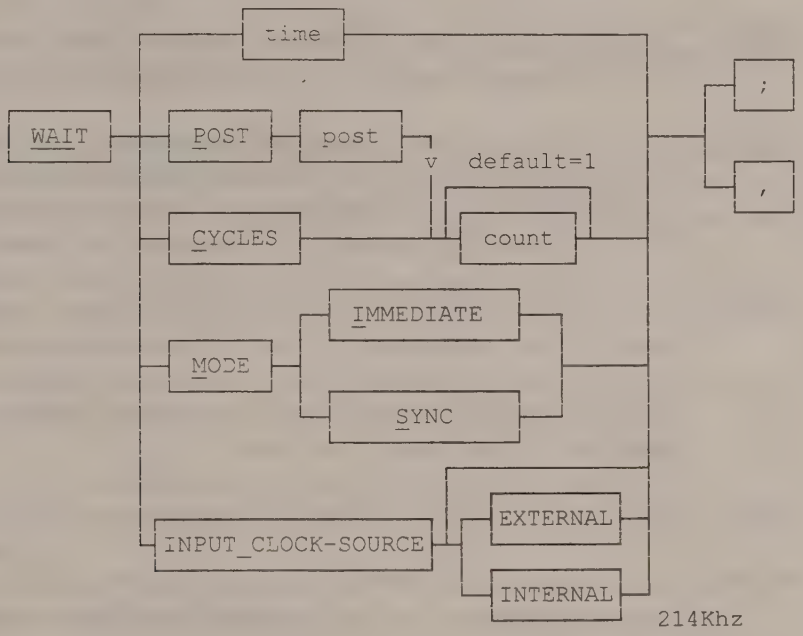
LSX; - command used to turn off Line Synchronous Mode .

NOTE: The frequency display on each module will change from 60 (50) Hertz to 60.000 (50.000) Hertz.. **Reset** of the Pulsar, either manually or by a computer will cause the Pulsar to **return to the Internal Synchronous Mode.**

4.7. Wait Command

This command provides a time delay before the next command is executed.

See following figure.



where:

WAI - indicates that this is a **wait** command.

time - indicates to wait the specified period of time in milliseconds (0.1 to 3276.7). This command was designed to work primarily in Synch Immediate and Self Zero mode. In all other modes, the timer first times out and then must wait for a zero degree pulse from the master generator before it signals all generators to continue command execution. That is, in all other modes the accuracy drops to the frequency of the master generator.

PITFALL: Commands strings like "a0,wai2;a1,wai2;a2,wai2;" must also wait for each semicolon to execute. The command string "v1,waimi,s,waic1,d1,waic1,wai1,d0,waic1,d2; would wait 0 to 16.666msec waiting for the zero degrees in the first cycle, 17.666msec waiting for the second cycle and the 1msec time and then 15.666msec waiting for the last cycle pulse to be generated.

P - indicates timer post events.

post - indicates to wait for activity on the specified timer **post** (1 to 3).

NOTE: To turn the generators off after a timer post event, enter WAIP1,V0C0,OFF; The first timer post event will start the sequence to turn the generators off.

count- indicates the number of post events required before generators will resume command execution. If the unit is not in Synch Immediate or Self Zero mode then the command will also wait for a synch pulse from the Master Generator after the count has expired before allowing the generators to continue.

NOTE: To turn the generators off after a timer post event, enter WAIP1,V0C0,OFF; The first timer post event will start the sequence to turn the generators off.

C - indicates wait until a cycle count is complete. This is a count of the master generator's phase reference pulse.

count- is the positive whole number with a maximum of 65535. The default count is 1.

NOTE: When in wait mode immediate and synch phase ref mode, "waimi,sp;", that the minimum allowed count is 2 and that "waic1" is interpreted as a "waic2" command.

PITFALL: Commands strings like "a0,waic2;a1,waic2;a2,waic2;" must also wait for sync pulses at each semicolon in synch phase ref. In wait mode immediate the first wait cycle in a series of waits will start asynchronously and produce a timing between (n-1) to n times period of the master generator(Ex. "waic2 ,waic2,;" gives a 16.6msec to 33.3msec wait followed by a 33.3msec wait).

M - indicates the mode of synchronization for the wait command.

MI - indicates that timing or counting will begin **immediately** after the previous timing or counting event has completed. This command takes effect immediately and cannot be sent while a wait command is waiting.

MS - indicates that timing will begin on the next master generator's synch signal after the previous timing or counting event has completed. This command takes effect immediately and cannot be sent while a wait command is waiting. This mode is useful in forcing the next wait event to start when the synch pulse is generated and not as soon as the previous wait event timed out.

NOTE: The synch signal in synch immediate or synch self-zero is the wait timers 50usec clock. The synch signal in synch phase ref and synch phase ref self zero is the master generators zero degree pulse.

PITFALL: Because the same pulse cannot cause a Wait Cycle time out and synch the next wait events start, Wait Cycle commands will wait an extra cycle when the synch signal is the master generators zero degree pulse.

I - indicates the input source for the generator's synchronization of wait timer events.

II - indicates that the clock source is internal (system generated). This is the default entry.

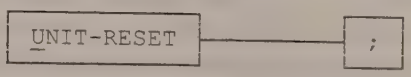
IE - indicates that the clock source is external (user defined).

Example:

WAI16.6; = wait 16.6 milliseconds.

4.8. Unit Reset Command

This command resets the unit to its power-up state (see section 6).



where:

U - indicates a **unit reset** command which resets the unit to its power-up state. This command executes immediately upon receipt and does not wait for synchronization (see section 4.6).

Example:

U; = reset unit to its power-up state.

4.9. Local Mode Command

If the PULSAR unit's front panel has been disabled because an attached controller has been communicating with the PULSAR unit via RS-232, the Local Mode Command re-enables front panel operation. Except for enabling or disabling the front panel, the "state" of the PULSAR unit does not change when going from remote mode to local mode or from local mode to remote mode.

where:

LOC - indicates that this is the Local Mode Command.

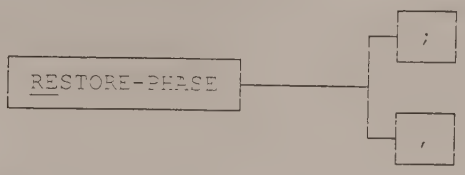
NOTE: The change to local mode cannot be made while timing events are going on.

Example:

LOCAL ; = re-enable front panel operation.

4.10. Restore Phase Command

This command restores the phase relationship of all selected generators (see the Generator Selection Command). When the frequency of a generator is changed, its phase relationship to the other generators will be unpredictable. To indicate this condition, the generator whose frequency is changed will show dashes at its phase display. The phase display will be restored when a Restore Phase Command is executed.



where:

RE - indicates that this is the restore phase command which restores the phase relationship of all selected generators.

NOTE: When this command is executed, each of the selected generators immediately jumps to its current phase setting.. If commands are being executed in immediate mode the phase will restored immediately. For a generator to remain in phase with the master generator in all synch modes, except self-zero, the master generator must be selected to be restored. If the phase of the master generator is not to be changed by the restore phase command, then the master generator must be phase restored in synchronous phase reference mode.

Example:

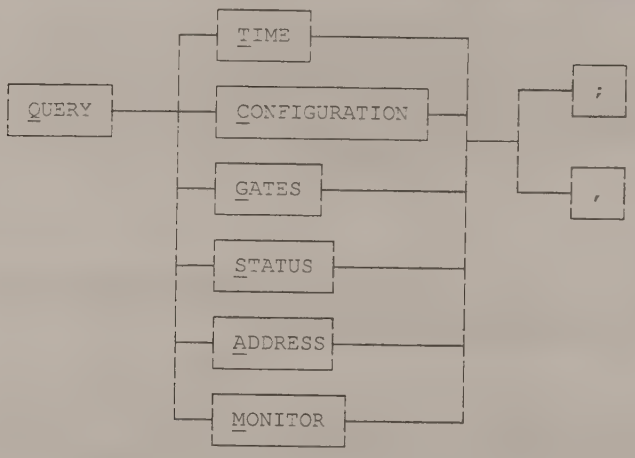
v0c0,sp;RESTORE ; = restore the phase relationship of all generators to the master generator.

v1,sp;re; = restore the phase of v1 with that of the master generator presumed to be c3.

v12,s;v1,re,v2,wai5,re; = phase of v1 and v2 will be 5msec apart;
v1ss;v1,p30,re; = when v1 reaches 0 degrees switch to 30 degrees (execute RE in sync self-zero).

4.11. Query Command

This command asks the PULSAR unit to transmit information back to the controller. This command is executed in the normal order, and is executed immediately upon receipt and does not wait for synchronization (see section 4.6).

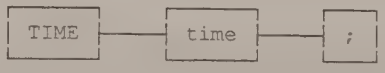


where:

Q - indicates the **query** command.
T - requests the timer's **time**.
C - requests **configuration**.
G - requests the state of the timer **gates**.
S - requests the wait **status** that is currently processing.
A - request the bit encoding of DIP switch SW2 on the system board.
M - requests the present monitor state.

QUERY TIME

For the **time** request, the PULSAR unit responds as follows:



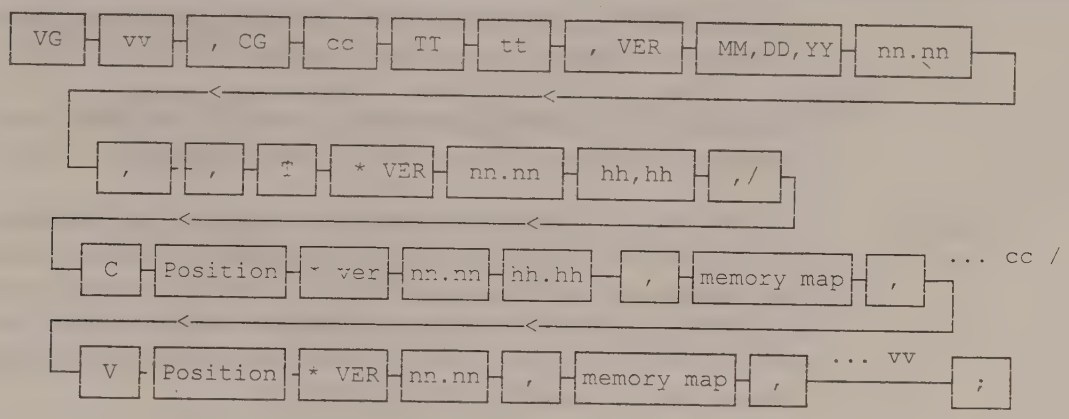
where:

TIME - indicates that this is the **time** response.

time - indicates the **time** in seconds.

QUERY CONFIGURATION

For the **configuration** request, the PULSAR unit responds as follows.



where:

VG - indicates that the number of **voltage generators** installed in the PULSAR unit will be indicated by the subsequent number.

vv - is the number of **voltage** generators.

CG - indicates that the number of **current generators** installed in the PULSAR unit will be indicated by the subsequent number.

cc - is the number of **current** generators.

TT - indicates that a **timer** unit installed.

tt - indicates the **number** of timer units installed. Currently only one timer unit can be installed.

MM.DD.YY - indicates the month, day and year of the system software.

VER - indicates the **version number** of the software in the PULSAR unit for the system software, the timer software, and the generator software within the PULSAR system.

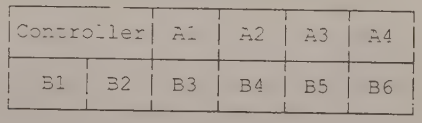
nn.nn - is the software version **number** of the generator module.

hh.hh - is the hardware version number of the generator module.

V - indicates that the **voltage generator** description will follow in the subsequent strings for the number of voltage generators (...vv).

C - indicates that the **current generator** description will follow in the subsequent strings for the number of voltage generators (...cc).

Position - indicates the location that the generator resides in the PULSAR unit. The positions start at the top with the first slot after the controller being A1. The highest and right most slot is A4. The bottom left most slot is B1 and the right most slot is B6. Current generators always take up the even slots (B2, B4, & B6). The bottom right most slot (B6) holds the system's phase reference generator (see section 4.6).



T - indicates that the **timer unit** description will follow in the subsequent string.

memory map - is used to pass the number of **memory locations** that can be used in conjunction with the waveform location commands (see section 4.2 and 4.3).

, - is a **delimiter** between the parameters that comprise this message ending in semicolon.

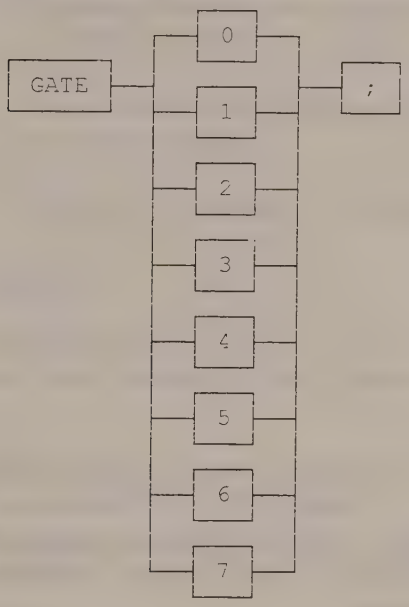
NOTE: The comma in the syntax diagram above has a typical delimiter function rather than the previously defined terminator function (see section 3.4). Since this comma is not interpreted within the PULSAR unit's software, its use here is not an inconsistency of the PULSAR unit.

/ - is a **delimiter** between the description of each main module within the PULSAR system (voltage generators, current generators, and the timer unit).

* - is a **delimiter** between the type of unit within the PULSAR system and the version descriptor.

QUERY GATE

For the **timer gate** request, the PULSAR unit responds as follows.



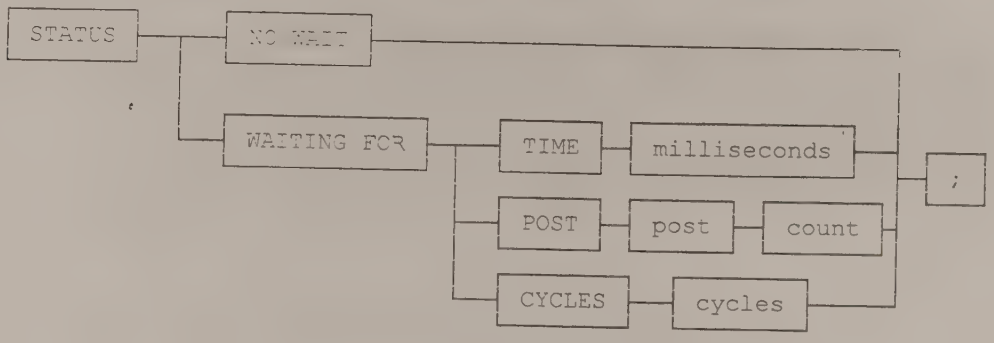
where:

GATE - indicates that this is the timer gate response for binding posts 1, 2, and 3. In the following table true indicates that the post is active, and false indicates that the post is not active. Note that the input required to make a binding post active when configured for applied is opposite that of remove.

digit sent	binding post 3	binding post 2	binding post 1
0 -	false	false	false
1 -	false	false	true
2 -	false	true	false
3 -	false	true	true
4 -	true	false	false
5 -	true	false	true
6 -	true	true	false
7 -	true	true	true

QUERY STATUS

For the request of the wait status that is currently being processed, the PULSAR unit responds as follows:



where:

STATUS - indicates that this is the response to the query for the **wait status** that is currently processing. The status option of the Query Command (for which this is a response) is used for diagnosing user software problems. If system operation appears to be suspended, this may provide a clue to the cause.

NO WAIT - indicates that when the status option of the Query Command was processed by the PULSAR unit, there were **no wait** commands currently being processed.

WAITING FOR - indicates that when the status option of the Query Command was processed by the PULSAR unit, the PULSAR unit's CPU board was currently **waiting for** the completion of the wait command (see section 4.7) indicated in the remainder of this command.

TIME - indicates that the **time** option of the wait command was in progress (see section 4.7).

milliseconds - indicates the number of **milliseconds** specified by the user in the time option (see section 4.7).

POST - indicates that the **post** option of the wait command was in progress (see section 4.7).

post - indicates that the **post number** option of the wait command was in progress (see section 4.7).

count - indicates that the **event count** option of the wait command for the selected post was in progress (see section 4.7).

CYCLES - indicates that the **cycles** option of the wait command was in progress (see section 4.7).

cycles - indicates the **number of cycles** in the cycles option (see section 4.7).

QUERY ADDRESS

For responses to query address PULSAR will respond with a single number indicating the GPIB address as selected on the system board.

```
number
```

number - indicates the bit encoding of dip switch SW2 on the system board.

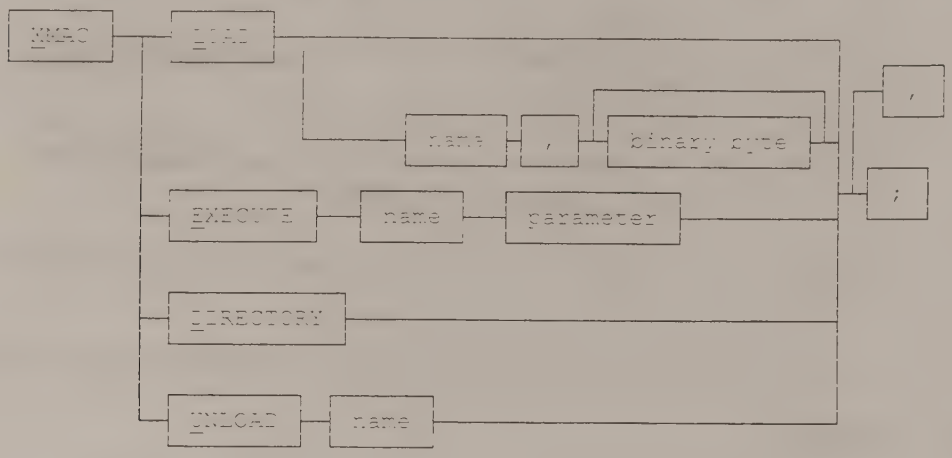
Query Monitor

Is similar to **Query Gate** except that it returns one byte that is a bit encode binary number between 0 and 7 set according to **Query Gate** table.

4.12. XMAC COMMANDS

These command allow programs in ".EXE" format, that have been linked with the library module supplied by AVO Multi-Amp, to be managed by PULSAR.

Syntax Diagram: see next page.



X - Indicates that this is a Xmac command.

L - Indicates that a Xmac program in ".EXE" format is to be loaded by PULSAR.

E - Indicates that a Xmac program in ".exe" format, previously loaded by PULSAR, is to be executed. The execution may be prematurely terminated if the unit receives the character '%' on RS232 or GPIB.

D - Requests that PULSAR output a list of the currently loaded Xmacs. Each item in the list is terminated by a CR LF (Carriage Return Line Feed) and the list is terminated with the message "6-00 Transfer Complete".

U - Indicates that a previously loaded Xmac program is to be unloaded by PULSAR, and that the program space should be freed for reuse. If a macro is executing, it will not be unloaded until execution of the macro has completed. The execution may be prematurely terminated if the unit receives the character '%' on RS232 or GPIB.

name - Is the macro Identification name. The name can be up to 8 ASCII characters maximum. The name must be followed by a comma. The name in the unload command can be followed by a semicolon.

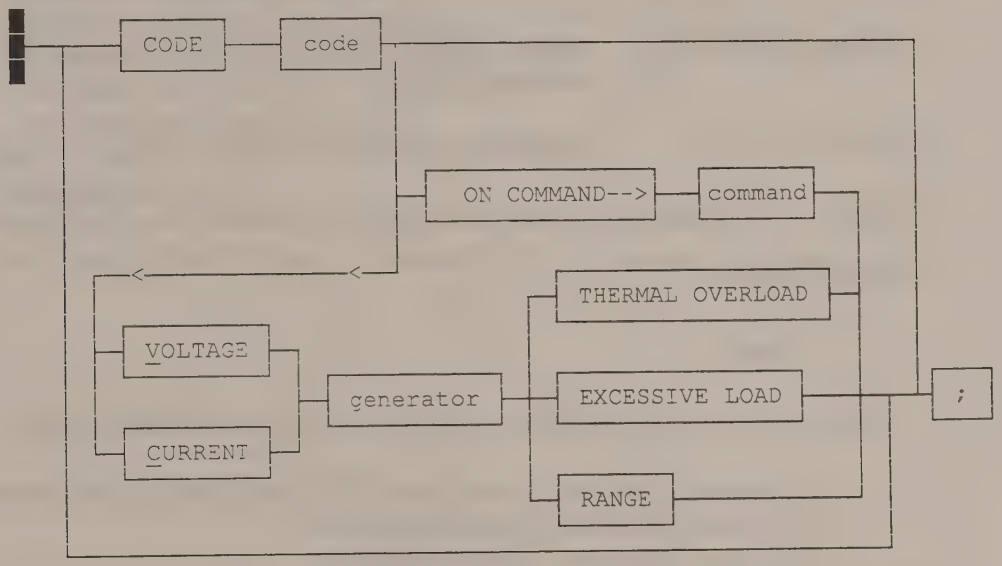
binary byte - Is an eight bit binary byte to be loaded by PULSAR.

parameter - Is an ASCII string that is passed to the macro program in the form of a parameter separated by spaces. The maximum number of parameters that can be passed to a macro is 15 and the combined string of Xmac name and parameters cannot be greater than 128 characters.

NOTE: The number of parameters must match the number expected by the Xmac program.

5. PULSAR Errors

Errors generated by a PULSAR unit are transmitted via the communication interface as follows.



where:

CODE - indicates that the **code** in the following box is for the alphabetic description subsequent to it, or that some other error has occurred for which a **code** has been defined but no alphabetic description is to be supplied.

code - a three digit **code** which defines the error or condition.

ON COMMAND--> indicates the last command parsed before the error occurred on the unit.

NOTE: When the PULSAR unit determines that a syntax error has occurred, all generators are shut off.

command - is the last input **command** parsed before the error occurred.

VOLTAGE - indicates that a **voltage** generator message is included in this message.

CURRENT - indicates that a **current** generator message is included in this message.

generator - a single digit in the range of 1 to 9 indicating the **generator** affected.

THERMAL OVERLOAD - **thermal overload** error condition exists in the generator.

EXCESSIVE LOAD - **excessive load** error condition exists in the generator.

RANGE - indicates that an **out of range** error condition exists in the generator.

6. Power-up State

6.1. Generators

Upon power-up the generators will be set up with the following options:

- All generators are set to the default OFF state which is as follows:
  Voltage Generator - High Impedance.
  Current Generator - High Impedance.
- All phases and amplitudes are set to zero.
- All frequencies are set to the value set by the internal jumper (either 50 or 60 Hz).
- Waveform storage is set to storage location 1.
- No generators are selected (see section 4.1).
- All generator ranges are set to the lowest range available see section 4.2). The range mode is set to autorange.
- Waveform 1 is set to fundamental frequency sine wave.
- On any generator's distortion error the outputs are shut off and the horn will sound.
- Load error on the generators outputs will not sound the horn or shut down the generators.

6.2. Timer

The timer will start up with the following default settings.

- The Synchronization Command is set to "P" (phase reference).
- The timer start and stop are set to the latched change of state mode.
- The third timer post is set to monitor continuity.
- The timer defaults to seconds.
- The timer start gate horn is disabled.
- The timer stop gate horn is disabled.
- The third timer post horn is disabled.
- The timer aux-contact is open.

6.3. Miscellaneous

The front panel of PULSAR will be enabled, i.e., the local mode will be in effect.

NOTES

NOTES

Appendix B

PULSAR ERROR CODES

PULSAR ERROR CODES

GENERAL INFORMATION ON ERROR CODES

Errors are displayed from the unit and are also transmitted over RS232 using a preset error message format.

Error codes are organized into sections according to the subsystem involved with the error. These sections are:

SECTION 1 - GENERATOR SELECTION SECTION
SECTION 2 - GENERATOR CONTROLLER
SECTION 3 - GENERATOR WAVEFORM SECTION
SECTION 4 - TIMER SECTION
SECTION 5 - GENERAL ERRORS
SECTION 6 - COMMUNICATION SECTION
SECTION 7 - WAIT COMMAND ERRORS
SECTION 8 - MACRO ERRORS
SECTION 9 - MACRO ERROR

Error codes are given in the form "section-subcode" i.e. 1-02, 2-02 etc... Generally the meaning of the subcodes change from section to section except in the case of syntax errors which have been assigned the following codes and report the same error regardless of section.

Syntax
A syntax error code is used for incoming commands that cannot be recognized by the PULSAR system. This error code can occur from the general error classification (5) or from one of the unit type classes (1, 2, 3, 4, or 6). An example of a syntax error is as follows:

The command "SI;" is entered. The error is because this command is invalid and not recognized by the PULSAR system. The command should have been "WAV1SI;".

X-01 SYNTAX-GENERAL SYNTAX ERROR

General or nonclassifiable syntax error. The unit received an unrecognizable series of characters.

X-97 SYNTAX-NO GENERATOR SELECTED

A command was received that requires that a current or voltage generator or some other subsystem, to have been previously selected.

X-98 SYNTAX-BAD COMMAND

The command interpreter did not recognize the command.

X-99 SYNTAX-NO NUMBER

A command was entered without a value. This happens when you enter amplitude, dc, phase, or frequency, and leave off the number. "Example: v1,a;" The "a" was entered without a value from 0 to 300 volts. This generates an error code 2-99.

SECTION 1 - GENERATOR SELECTION SECTION

1-02 SELECTION ERROR

A generator selection error is caused when a generator is requested that does not exist. If a system has voltage units 1 and 2 present and voltage unit 3 is requested, the generator selection error occurs. An example of a generator selection error is as follows: The command "V3," is entered. The only valid entries were "V12,", "V1,", "V2;", or "V0;", therefore a generator selection error is created.

SECTION 2 - GENERATOR CONTROLLER SECTION

2-02 AMPLITUDE VALUE ERROR

An amplitude value error occurs (1) when an amplitude is entered outside the range of the selected generator or (2) when the generator is not in auto- range mode and on. (1) Suppose the range of the selected current generator is 3. If a request is made to have the amplitude set to 3.1, which is the next range category, an amplitude error occurs. (2) Suppose the range of the selected current generator is 30 and the generator is on, and not in autorange mode. If an amplitude of 3 is requested, an amplitude error occurs.

2-03 DC VAL ERROR

A DC value error occurs (1) when a DC value is entered outside the range of the selected generator or (2) when the generator is not in auto- range mode and on. (1) Suppose the range of the selected current generator is 3. If a request is made to have the DC value set to 3.1, which is the next range category, a DC error occurs. (2) Suppose the range of the selected current generator is 30 and the generator is on, and not in autorange mode. If a DC value of 3 is requested, a DC error occurs.

2-04 DC AMP SUM ERROR

A DC_AMP sum error occurs when the absolute value of the DC value plus the AC value caused a range switch when the generator is on, or when the values added together exceed 300, which is the max DC + AC value.

2-05 DC AMP EXPONENTIAL SUM ERROR

A DC_AMP_EXP sum error occurs when the absolute value of the DC value plus the AC value plus the EXPONENTIAL OFFSET causes a generator to exceed the current range selected by the generator.

2-06 PHASE VALUE ERROR

A phase error occurs when the user enters a value greater than 999.9 or less than -999.9. If a phase value of 1000 was requested of PULSAR, then a phase value error would occur.

2-07 FREQ VALUE ERROR

A frequency error occurs when the user enters a value greater than 20,000Hz, or when a value of less than 1Hz is entered on the phase reference generator. If a frequency value of 20001 was requested of PULSAR, then a frequency value error would occur.

2-08 OFF STATE ERROR

An off state error happens when the user selects an off state greater than 3 and less than 0. The command should be entered as follows: "OFF 1;", "OFF 2;", or "OFF 3;".

2-09 WAVE N LOCATION ERROR

The valid wave locations are 1 thur 16. If the user enters a waveform location greater than 16 a waveform location error is generated. If the command "WAV17," was requested of PULSAR, then the waveform location error would be generated by PULSAR.

2-10 WAVE LOCATION MEMORY ERROR

The waveform location selected has memory errors at that position. Consult the generator configuration response and look into the waveform location - 1 to see the cause of the problem.

SECTION 3 - GENERATOR WAVEFORM SECTION

3-02 WAVE LOCATION ERROR

The valid wave locations are 1 thur 16. If the user enters a waveform location greater than 16 a waveform location error is generated. This error code is used to represent the selection and execution of an existing waveform location. Therefor a different section and error code was chosen. The same rules apply for this waveform location error as the waveform location error described in Section 2.

The waveform location selected has memory errors at that position. Consult the generator configuration response and look into the waveform location - 1 to see the cause of the problem.

3-03 SINE AMP VALUE ERROR

The sine value entered cannot be greater than 1. If the user selects a sine value greater than 1 then a sine value error is generated. The sine amplitude input to PULSAR must be >= 0 and <= 1. A command of "WAV1SI 1.1:10:10;" submitted to PULSAR would generate a sine amplitude value error would be generated, because 1.1 is greater than 1.

3-04 SINE AMP OVERFLOW ERROR

The sine value entered cannot be greater than 1. If the user selects a sine value of .3 and .8, when entering multiple sine commands within the same waveform location, or any combination that is greater than 1 a sine amplitude overflow error occurs. Suppose the following command was requested of PULSAR:

"WAV1SI.4:20:30 .5:10:10 .2:15:10,"

A sine amplitude overflow error would be generated at the ".2" because .4 + .5 + .2 is greater than 1.

3-05 SINE HARMONIC VALUE ERROR

A sine harmonic error occurs when a value is enter that is less than 1 or greater than 50. If the command "WAV 5 SIN .7:51:120;" was submitted to PULSAR, a sine harmonic value error would be generated by PULSAR. This occurs because 51 is not in the range of 1 to 50.

3-06 SINE PHASE VALUE ERROR

A phase error occurs when the user enters a value greater than 999.9 or less than -999.9. A command of "WAV 7 SIN .2 : 50 : 1000," generates a sine phase value error. The phase value of 1000 is outside the range of -999.9 to 999.9.

3-07 TRIANGLE DUTY ERROR

A triangle duty error occurs when the user enters a value less than 0% or greater than 100%. A command of "WAV 1 T 101;", generates a triangle duty error because 101 is not in the range of 0 to 100%.

3-08 SQUARE DUTY ERROR

A triangle duty error occurs when the user enters a value less than 1% or greater than 100%. A command of "WAV 1 SQ 101;", generates a square duty error because 101 is not in the range of 0 to 100%.

3-02 WAVE LOCATION MEMORY ERROR

The waveform location selected has memory errors at that position. Consult the generator configuration response and look into the waveform location - 1 to see the cause of the problem.

3-10 EXPONENTIAL DC VALUE ERROR

An exponential DC value error occurs when a DC value is entered outside the range of the selected generator. Suppose the range of the selected current generator is 3. If a request is made to have the DC value set to 3.1, which is the next range category an exponential DC error occurs. The command string that would cause the error is "WAV 10 E 3.1:100;".

3-11 EXPONENTIAL TIME CONSTANT VALUE ERROR

An exponential timer constant error occurs when the user specifies a timer constant decay less than 1 or greater than 10,000 milliseconds. A command of "WAV 12 E 2.5:11000," would generate a exponential time constant value error. A value of 11,000 milliseconds is not supported by PULSAR.

3-12 EXPONENTIAL AUTO RANGE ERROR

An exponential auto range error occurs when the user specifies an exponential waveform request and the generator is in auto range mode. The following example would result in an error: First the command "RA 0;" is submitted to PULSAR. Next the command "WAV 1 E 3:1000;" is submitted to PULSAR. The exponential auto range error would be generated by PULSAR. If the first command would have been "RA 30;", then no exponential auto range error is generated by PULSAR.

3-13 EXPONENTIAL OVERFLOW ERROR

This message is received from the Sine Gen when the DC offset 'k' of the command "WAVEk:t" causes the exponential decay to go outside the current range set by the RANGE command.

SECTION 4 - TIMER SECTION

4-02 POST VALUE ERROR

The timer post value error is similar to the generator select error. There are only 3 timer post values (1, 2, and 3). If a selection outside this range is requested a timer post value error is generated. A selection of 0 is allowed, and selects all three post. A selection of "T4;", is invalid and generates a timer post value error.

4-03 DEBOUNCE VALUE ERROR

The timer debounce error occurs when the user specifies a number less than 0 or greater than 1638.3 milliseconds. A "TD1000" command generates a timer debounce value error.

4-04 CYCLES VALUE ERROR

The timer cycles error occurs when the user specifies a number less than 0 or greater than 20,000Hz. Any command outside the range of 0 to 20,000Hz generates a cycles value error ("TC21000" is and error).

4-05 TIMER SYNC TEST ERROR

This error occurs when the user does not have at least 2 generators selected, and an attempt is made to run a synchronization test.

EXAMPLE: V1,TSY;

To prevent an error the user should have entered
V12,TSY;

NOTE: The correct way to setup the test is as follows: T1CAL;T1STA,TSY; This sets up Timer post 1 in the Continuous applied latched mode, configures post 1 to start, and causes the synchronization test to begin.

4-06 THERMAL ERROR TIMER

A thermal overload error condition exists in the timer (battery simulator section).

4-07 TIMER POST ERROR

A timer post interrupt was received that was invalid. The only valid bits are bit 0, bit 1, and bit 3 from the MSR1 (modem status) register.

SECTION 5 - GENERAL ERRORS

5-02 INPUT BUFFER FULL

The input buffer full error happens when the PULSAR external input buffer is overflowed with incoming commands. The commands requested are flushed. The input buffer could be come full if 1) the incoming commands were being shipped to PULSAR, and 2) the generators and timer buffers became filled, and 3) the external controller still kept sending commands until the main system buffer became full. When this occurs there is no more room to store incoming messages and it is determined that the external controller has to be shut down until we are able to accept messages again.

5-03 INPUT BUFFER EMPTY

The input buffer empty message happens when the PULSAR external input buffer has returned to normal state, and new messages can be sent.

5-04 OUTPUT BUFFER FULL

The output buffer full error happens when the PULSAR output buffer overflows. This occurs when the user adds too many loop backs into the commands that can be grouped together without a comma or a semi-colon. An example of this type of command is the sine function, which is located in the generator waveform command section. The generator's input buffer becomes full while other commands are being submitted by the external controller and thus this error is generated.

ERRORS 5 THROUGH 8 ARE SIMULATION ERRORS ONLY, AND NOT A PART OF THE TARGET SYSTEM.

5-05 FILE OPEN ERROR

The file open error occurs in the PULSAR batch mode. The input file could not be opened because the filename was incorrectly specified.

5-06 DEBUG FILE OPEN ERROR

The debug file open error occurs in the PULSAR batch mode. The output file could not be opened because the filename was incorrectly specified, or because there is not enough room on the disk for the file.

5-07 WRITE ERROR

The file write error occurs in the PULSAR batch mode and simulation modes. This error occurs because the disk is full or there is problems with the system being used.

5-08 READ ERROR

The file read error occurs in the PULSAR batch mode and simulation modes. This error occurs because the disk media has problems or the system being used has problems.

5-09 RANGE ERROR

A range error occurs when a request is made to lower the range below the DC value and the amplitude value. If a voltage unit was selected and the amplitude and DC values were 35 and 60 respectively, and a request was made to have the range be 25, a range error occurs. This is an attempt to leave the 300 volt range and move to the 30 volt range with the amplitude and DC values being in the 300 volt range.

5-10 DC AMP SUM ERROR

A DC_AMP sum error occurs when the absolute value of the DC value plus the AC value caused a range switch when the generator is on, or when the values added to gather exceed 300, which is the max DC + AC value.

5-11 DC AMP EXPONENTIAL SUM ERROR

A DC_AMP_EXP sum error occurs when the absolute value of the DC value plus the AC value plus the EXPONENTIAL OFFSET causes a generator to exceed the current range selected by the generator.

5-12 THERMAL ERROR GENERATOR AMP
5-13 THERMAL ERROR GENERATOR POWER SUPPLY

A thermal overload error condition exists in the generator or power supply.

5-14 EXCESSIVE LOAD ERROR

An excessive load error condition exists in the generator.

5-80 POWER FACTOR CORRECTOR THERMAL OVERLOAD ERROR

The power factor corrector in the Input Power and Control module has reported thermal overload problems.

5-15 WAIT QUE FULL

This error occurs when more than 16 wait commands are presented to PULSAR without a semicolon to cause execution of the wait commands. For example, if the command string:

"w1,w2,w3,w4,w5,w6,w7,a3,p3,w1,w2,w3,w4,w5,w6,w7,a20,w2,w3,p30,w4;", was submitted to PULSAR, a wait queue full error would be generated by PULSAR.

5-16 INVALID WAIT SYNC TIMER 0
5-17 INVALID WAIT SYNC TIMER 1

This error occurs when PULSAR is requested to parse two wait commands of 50 microseconds each. An example of this error message being generated is as follows:

"w1,w1,a30,w2;" causes the two PULSAR timers to time out before the system can get around to processing the "w2" part of the string. Therefore, the invalid wait sync error message is generated by PULSAR.

These errors are used to identify errors to cover cases 010, 101, and other timer errors. In the non debug system mode, this error is used to identify what state the timer was in when the error occurred.

5-18 WAIT TIMER HARDWARE ERROR

This error occurs when more than four syncs are generated by the system. An example of this error is a wait sync immediate, sync phrase ref, followed by three wait 1's.

"ws,sp,w1,w1,w1;" causes more than four sync's to be generated before one can be processed. Therefore, a timer hardware error is generated.

5-19 WAIT TIMER MISCELLANEOUS ERROR

State 010 or 101 was attempted to be used. These states should be used in test mode only.

5-20 WAIT TIMER STATE 0 TIMEOUT ERROR

A timer timed out at state 0. We expected no timer time out.

5-21 WAIT TIMER STATE 1 TIMEOUT ERROR

Timer 1 timed out in State 1. Timer 0 should have timed out.

5-22 WAIT TIMER STATE 3 RELOAD ERROR

This error occurs in state 3. Timer 0 timed out before we got around to re-loading it. The system has fallen behind and the timing is off.

5-23 WAIT TIMER STATE 3 TIMEOUT ERROR

In state 3 we expect timer 0 to time out, or to receive a packet. We received a timer 1 time out. The system has fallen behind.

5-24 WAIT TIMER STATE 4 ERROR

In state 4 we should receive a new packet. We had a timer time out. Suspected that the system has fallen too far behind.

5-25 WAIT TIMER STATE 6 ERROR

In state 6 we expect to receive a packet or to have timer 1 time out. Timer 0 timed out. The system has fallen behind.

5-26 WAIT TIMER STATE 7 ERROR

In state 7 we expect timer 1 to time out or to receive a packet. We also expect to load timer 1 before it times out. The system has fallen behind and the timing is off.

5-27 WAIT TIMER ERROR

We received a timer 0 time out. We expected to receive a timer 1 time out or to receive a packet.

5-28 NO SYSTEM BUFFERS

This error occurs when no system buffers can be allocated. This is caused when the system is not started properly.

5-29 NO MACRO BUFFERS

This error occurs when no macro slots are available in the MACRO memory table. For example, the user request to load a MACRO program, but there is no slots available for MACRO programs. The suggested action to take is to unload 1 MACRO program to open a slot for the new MACRO program.

5-30 NO MACRO MEMORY

This error occurs when no macro buffers are available to the PULSAR system. For example, the user request to load a MACRO program, but the program will not fit in the Macro memory slot. The suggested action to take is to unload MACRO programs until space is available, or decrease the size of the MACRO program.

5-31 NOT AN EXE

This error occurs when the file requested to be loaded as a macro by PULSAR is not a ".EXE" file. PULSAR checks to see if the file meets ".exe" program specifications. To correct the problem, load a ".exe" file.

5-32 EXE TOO BIG

This error occurs when the file requested is larger than 32k. Currently Macro space is limited to 32k.

5-33 EXE NOT FOUND

This error occurs when the requested MACRO is not found in the Macro table. This error is generated when the EXECUTE, UNLOAD, or CANCEL, macro commands are used and the MACRO does not exist in the Macro table.

5-34 DUPLICATE EXE

This error occurs when the requested MACRO is duplicated in the Macro table. If the MACRO is to replace a MACRO in ROM this error will not be generated. This error is generated when the LOAD macro command is used.

5-35 MACRO SYNTAX

A syntax error was found in part of the macro command. When the Macro commands are parsed, a validity check is made to see that commas, semi-colons and spaces are in the correct positions. If the command cannot be interpreted this error is generated.

5-36 MACRO CHECKSUM ERROR

The MACRO was not loaded properly. A byte or bytes were lost during the transfer of the MACRO.

5-37 MACRO NORMAL COMPLETION

The MACRO has executed normally, and has completed.

5-38 MACRO CANNOT BE CANCELED

The MACRO cannot be canceled because it is waiting on system resources. A unit reset can be performed and then a MACRO CANCEL COMMAND can be made to cancel the macro.

5-39 PHASER GENERATOR NOT PRESENT ERROR

If a generator is not in the bottom right slot and a generator is not in the top right slot (satellite box) then a phaser generator error is generated by the system. The "SP" sync phase ref command is not allowed if this error is present.

5-40 INPUT CLOCK SOURCE ERROR

The user specified an incorrect internal clock source.

SECTION 6 - COMMUNICATION SECTION

6-02 COMMUNICATIONS INIT ERROR
6-20 COMMUNICATIONS INIT ERROR A

The external communications port failed during communications. The suspected problem is that communications was lost between the DSP and the System Software. The code used to report the error is dependent on the routine that detected the error.

6-03 COMMUNICATIONS OVERFLOW

The external communications port connected to the user has had data overwritten. This occurs when external commands are sent faster than the PULSAR system is capable of accepting and processing the commands.

6-04 UNIT UNAVAILABLE
6-07 UNIT UNAVAILABLE A
6-08 UNIT UNAVAILABLE B
6-09 UNIT UNAVAILABLE C
6-10 UNIT UNAVAILABLE D
6-11 UNIT UNAVAILABLE E
6-12 UNIT UNAVAILABLE F
6-13 UNIT UNAVAILABLE G
6-14 UNIT UNAVAILABLE H
6-15 UNIT UNAVAILABLE I
6-16 UNIT UNAVAILABLE J
6-18 UNIT UNAVAILABLE L
6-19 UNIT UNAVAILABLE M

These errors occur when a unit within the PULSAR system has communication problems. This error is a result of a generator or timer module going offline after being detected as present when the PULSAR system was initialized. The particular error codes indicates which section of the system software detected the error.

6-05 PULSAR ADDRESS ERROR

For future applications.

6-06 AUTO SHUT DOWN

This message is used when the timer sent an auto off message to PULSAR. This is not an error and should not be reported as such.

6-22 COMMUNICATION BUSY MAIN ERROR
6-23 COMMUNICATION BUSY ERROR

6-24 COMMUNICATION BUSY A ERROR
6-25 COMMUNICATION BUSY B ERROR
6-26 COMMUNICATION BUSY C ERROR
6-27 COMMUNICATION BUSY D ERROR
6-28 COMMUNICATION BUSY E ERROR

Communications with a DSP has halted. The DSP has locked up. The particular code used depends on the routine that detected the error.

6-29 COMMUNICATION BYTE COUNT ERROR

Communications with a DSP experienced a byte count error.

6-30 BAD DSP OPCODE ERROR

A DSP received a bad opcode during communications with the system board.

6-31 BAD DSP OPERAND ERROR

A DSP received a bad operand during communications with the system board.

6-32 COMMUNICATION SYNC ERROR

A DSP a sync error during communications with the system board.

6-33 COMMUNICATION WAIT ERROR

A DSP detected a wait error during communications with the system board.

6-34 COMMUNICATION UNDETERMINED ERROR

A DSP detected an error whose source was undetermined during communications with the system board.

6-35 MACRO LINE SET ERROR

6-36 DFR LINE SET ERROR

SECTION 7 - WAIT COMMAND ERRORS

NOTE: **"w" is used to stand for "wai" to shorten the length of the demo command strings.**

7-02 INVALID WAIT POST

The timer unit within PULSAR has 3 posts. If a post value of greater than 3 or less than 1 is requested with the wait command, an invalid wait post error is generated by PULSAR. An example of the invalid wait post error is as follows: "wait post 4".

7-03 INVALID WAIT POST COUNT

The maximum count that can be entered to represent the number of times a post can have the same event occur is 32,768. The minimum number that can be entered is 1, which is the default value. If the post wait count is greater than 32,768 or less than 1, then an invalid wait post count error is generated. An example of this error being generated is as follows:

"wait post 1 0;" or "wait post 2 70000;".

7-04 INVALID WAIT TIME

The invalid wait time error message is generated when the PULSAR unit is requested to process a wait time greater than 32,768.

7-05 INVALID WAIT CYCLES

The invalid wait cycles error message is generated when the PULSAR unit is requested to process a wait time greater than 32,768.

7-06 SYNC ON WAIT QUEUE NOT EMPTY

The sync on wait queue not empty error message is generated by PULSAR when a request is made for PULSAR to switch methods of using the wait timers before all of the wait commands have been emptied from the wait queue. For example, if the string:

"wsi,a20,w250,d50,w1000.8,wsp;", was submitted to PULSAR a sync on wait queue not empty would be generated by PULSAR. In this example the requestor attempted to change from the sync immediate mode to the sync on phase reference mode while PULSAR timers were still timing.

7-15 WAIT QUEUE FULL

This error occurs when more than 16 wait commands are presented to PULSAR without a semicolon to cause execution of the wait commands. For example, if the command string:

"w1,w2,w3,w4,w5,w6,w7,a3,p3,w1,w2,w3,w4,w5,w6,w7,a20,w2,w3,p30,w4;", was submitted to PULSAR, a wait queue full error would be generated by PULSAR.

7-16 WAIT QUEUE TIMER OVERFLOW ERROR

FROM SYSTEM SOFTWARE:

This error occurs when more than 16 wait commands are presented to PULSAR and the system is in the sync phase ref mode, which relies on the frequency and zero crossing to get sync pulses. The commands are being sent faster than the system can process sync pulses at the set frequency.

Example:

c3,waimi,sp,f1,re;wai1,wai1,wai1,wai1,wai1,wai1...up to more than 17 wait commands.

SECTION 8 - MACRO ERRORS

SECTION 9 - MACRO ERRORS

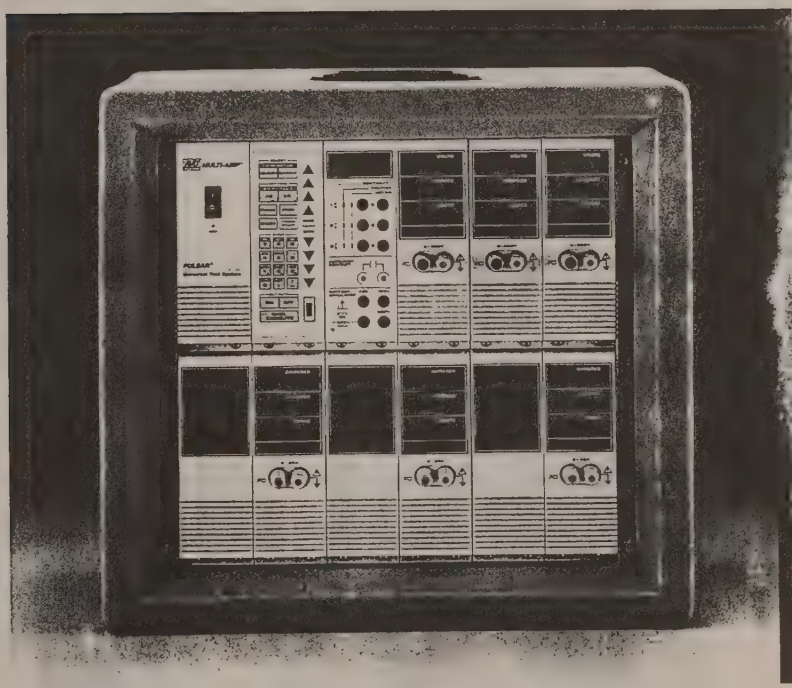
These sections are reserved for user defined errors to be generated by **Xmacs**.

Appendix C

PULSAR Product Specification

PULSAR

A COMPLETE THREE-PHASE RELAY TEST SYSTEM IN ONE PORTABLE PACKAGE.

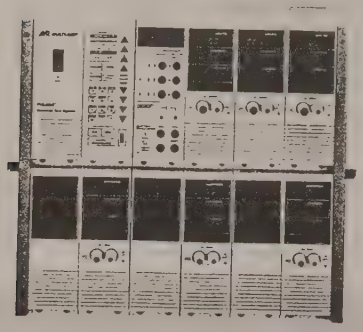


Now with150-VA Current-Amplifier Module

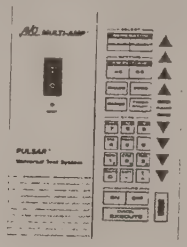
MULTI-AMP

CONTENTS

PULSAR Universal Relay Test System Overview 3



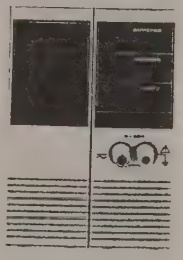
PULSAR Input Power and Control Module 6



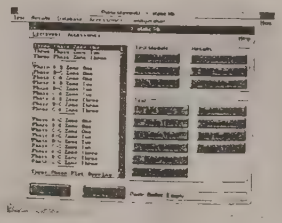
PULSAR Timer, Monitor and Battery Simulator Module 8

PULSAR Voltage Amplifier Module 10

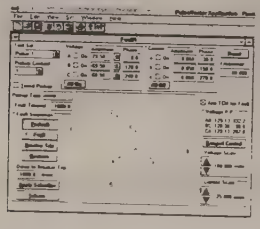
PULSAR Current Amplifier Module 12



PulseMaster 2.0 Software Package 14

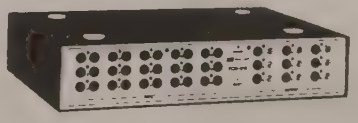


PulseVector™ Software Package 19

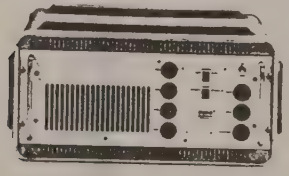


PULSAR High-Current Interface Module 21

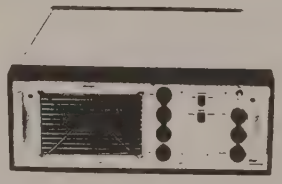
PULSAR Timer-Control-Monitor Unit 23



EPOCH-20® High-Current Output Unit 25



EPOCH-II® High-Current Output Unit 27



Cover photo:
Multi-Amp® PULSAR in field enclosure

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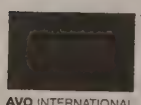

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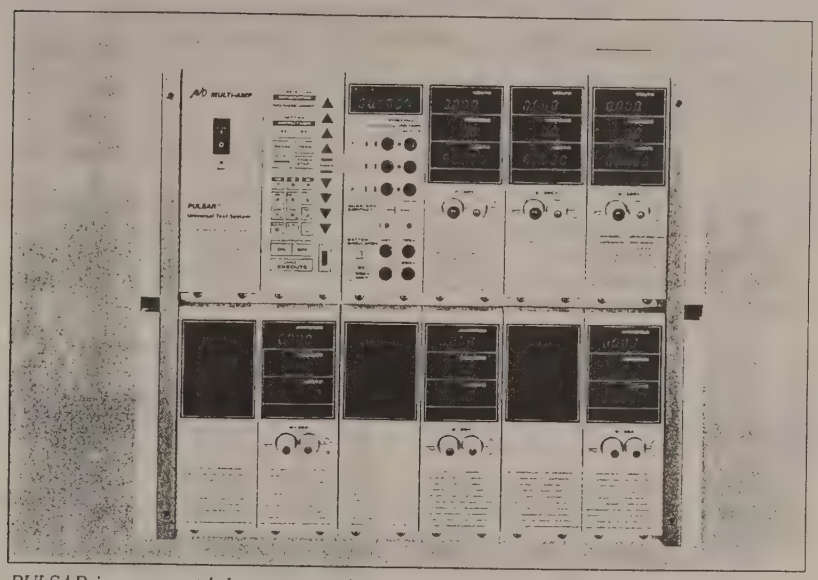


PULSAR in compact laboratory enclosure

MULTI-AMP PULSAR

- **Complete three-phase test system in one unit**
- **Modular design for system customization**
- **Steady-state and dynamic testing**
- **Transient testing via DFR replay and EMTP/ATP simulation**
- **Capable of GPS satellite synchronized testing**

Universal Protective Relay Test System

DESCRIPTION

The Multi-Amp PULSAR Universal Protective Relay Test System represents the next generation in protective relay testing. This one-unit, modular system lets you select the testing capabilities you need now and expand as your requirements change.

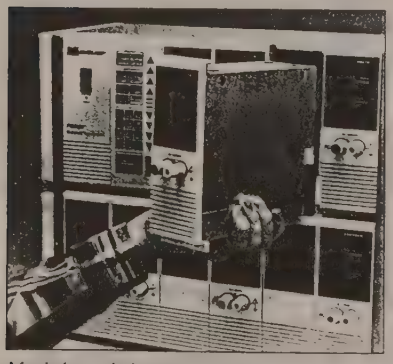
The PULSAR base unit includes the chassis, back plane, and input power and control module.

Current and Voltage Amplifier Modules

The system is customized by adding a timer module and the number of current and voltage amplifier modules needed for specific testing applications.

For example, adding the timer, one current amplifier module and one voltage amplifier module to the base unit provides a variable ac/dc current and voltage output, adjustable phase angle and frequency settings, and comprehensive control, timing and monitoring circuits. This configuration tests single-phase relays.

Add up to three current and three voltage amplifier modules to create a full, three-phase relay test system in one portable unit.



Modules slide out easily so you can configure the system to meet your applications.

High-Current Output Units and Interface Module

For high-current applications, PULSAR can be connected to the Multi-Amp EPOCH-20 and EPOCH-II High-Current Output Units. The Multi-Amp High-Current Interface Module provides the control interface between PULSAR and the EPOCH-20 or EPOCH-II to provide high-current, high-volt/ampere output for single-, three- or six-phase testing. For specifications on the Interface Module, the EPOCH-20 and EPOCH-II, refer to catalog entries for these models.

Designed for Convenience

PULSAR is small and lightweight enough to be carried to job sites by one technician. For durability, the unit is housed in a rugged field enclosure for use at substations and power plants.

PULSAR performs computerized tests with IBM or compatible PCs, even notebooks.

PULSAR is designed for easy setup and operation. A standard wall outlet is the only power source needed.

High-intensity LEDs display all outputs throughout the test, and PULSAR automatically changes output ranges to reduce testing time.

Manual or Computerized Control

PULSAR can be operated manually by simple, front-panel controls or combined with any IBM or compatible PC and the Multi-Amp PulseMaster software package for automated steady-state, dynamic and transient testing.

APPLICATIONS

PULSAR is designed to test virtually any relay, from simple overcurrent relays to complex three-phase relays requiring phase-shifting capability. This table lists relays by IEEE device number and matches them with the required combination of current and voltage amplifier modules.

IEEE Device Number	Relay Types	Select Modules (Qty) Based on Relay Type
2	Time-Delay Starting Relay	**PULSAR Base Unit plus:**
21	Distance (1ϕ)	1 Voltage Amplifier
24	Volts/Hertz	1 Current Amplifier
27/59	AC/DC Under/Overvoltage Relay	1 Timer, Monitor and Battery Simulator Module
32	Directional Power (1ϕ)	
37/76	DC Under/Overcurrent Relay	
40	Loss of Field	
50	Instantaneous Overcurrent (up to 30 A)*	
51	Overcurrent (up to 30 A at 150 VA)*	
67	Directional Overcurrent	
67N	Ground Directional Overcurrent	
81	Frequency	
82	DC Reclosing Relay	
85	Carrier or Pilot Wire Relay	
86	Lock-out Relay	
94	Tripping Relay	
	All the above relays plus:	**PULSAR Base Unit plus:**
21	Distance (open-delta)	2 Voltage Amplifiers
21G	Distance, Ground	2 Current Amplifiers
25/25A	Synchronizing/Auto-Synch	1 Timer, Monitor and Battery Simulator Module
46	Phase Balance Current	
47	Phase Sequence Voltage (open-delta)	
79	AC Reclosing Relay	
87	Differential	
50	Instantaneous/	
67/51	Directional Overcurrent (up to 60 A at 300 VA)*	
	All the above relays plus:	**PULSAR Base Unit plus:**
21	Distance (3ϕ wye) Voltage and Current.	3 Voltage Amplifiers
32	Directional Power (3ϕ)	3 Current Amplifiers
46N	Negative Sequence Overcurrent	1 Timer, Monitor and Battery Simulator Module
50	Instantaneous/	
67/51	Directional Overcurrent (up to 90 A at 450 VA)*	

* For higher currents or volt-amperes, refer to catalog entries on these models.

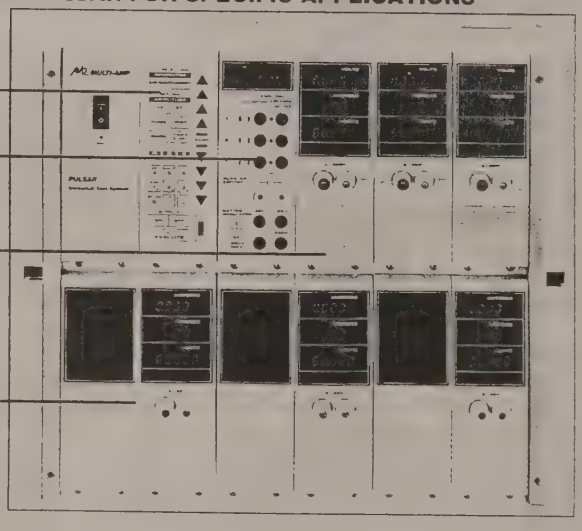
CUSTOMIZE PULSAR FOR SPECIFIC APPLICATIONS

Base unit includes Input Power and Control Module

Add to the base unit the Timer, Monitor and Battery Simulator Module

Add one, two, or three Voltage Amplifier Modules

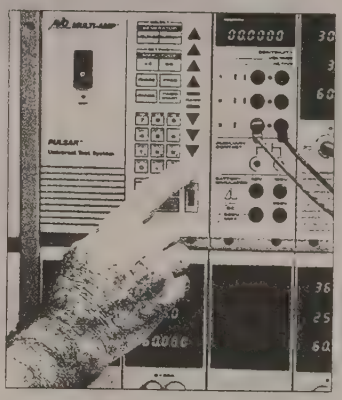
Add one, two, or three Current Amplifier Modules



FEATURES AND BENEFITS

- **Complete, three-phase test system:** PULSAR can be configured to provide complete three-phase variable current, voltage, frequency, phase angle, dc voltage, dc current, control, timing and monitoring functions.

- **Unique, modular design:** PULSAR modules plug in and slide out easily for system configuration. You can purchase any number of modules for configuration using one or more PULSAR units. This feature also allows for prompt replacement of modules during service.



Under manual control, you can easily change settings with the ramp up-and-down keys.

- **Simple, manual control:** With the system's multiple-channel outputs, you can easily change amplitude, phase angle or frequency settings by pushing the ramp up-and-down keys.

- **Totally automated testing:** PULSAR, combined with the advanced software capabilities of PulseMaster, automates steady-state and dynamic testing, and performs transient testing via DFR replay or EMTP/ATP simulation.

- **Steady-state and dynamic testing capability, including dc offset:** Either manually through front-panel controls or via computer control, the operator can test virtually any relay.

- **Performs transient tests:** Acceptance tests or troubleshooting can be accomplished by replaying digitally recorded faults or EMTP simulations in the IEEE COMTRADE Standard C 37.111-1991.

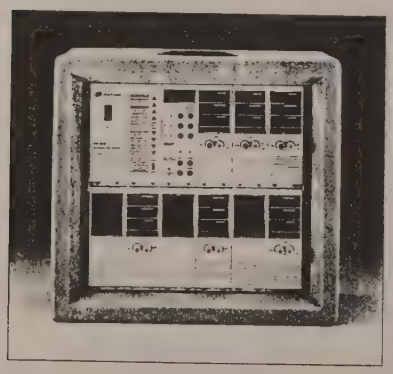
- **Performs end-to-end tests:** When combined with PulseMaster software and a portable GPS satellite receiver, PULSAR performs satellite-synchronized, end-to-end dynamic or transient tests for troubleshooting complex protection schemes.

- **Continuous LED displays:** Large, high-intensity LEDs remain active even

when the test set is under computer control so the operator can see all outputs all the time. Amplitudes, phase angle and frequency of all current and voltage outputs are displayed continuously and simultaneously.

- **Automatic range changing:** PULSAR automatically performs range changes under load to reduce testing time.
- **Immediate error indication:** Audible and visual alarms signal when amplitude, phase angle or waveform of the outputs is in error.
- **Wide-frequency bandwidth:** This feature provides the current and potential outputs to second, third and fifth harmonic, or virtually any desired harmonic within the operating range of the unit.
- **Creates user-defined waveforms for special test applications:** The operator can use any computer to generate square waves, triangle waves, half-wave sine waves and analytical sine waves. This includes per-unit values of amplitude, selected harmonics at various phase angles and dc offset with exponential decay.
- **Built-in RS-232 interface:** The interface works with standard communication ports on any IBM or compatible computer, even a notebook PC.
- **Tests high instantaneous relays:** Output of two or three current amplifier modules can be connected in parallel to increase the maximum current available to 60 amperes (two modules) or 90 amperes (three modules) for testing high instantaneous overcurrent relays.

Output potential of two voltage amplifier modules can be summed together to increase the maximum potential to 600 volts if the load is not grounded for testing high instantaneous overvoltage relays.



PULSAR in field enclosure

SPECIFICATIONS

Temperature Range

Operating: 32 to 122° F (0 to 50° C)

Storage: –13 to +158° F (–25 to +70° C)

Humidity Range

0 to 90% RH, noncondensing

Environmentally Tested

To simulate the worst field conditions, PULSAR was tested in accordance with MIL-STD-810 for temperature, shock and vibration resistance.

Enclosure

For field use, PULSAR can be ordered housed in a tough, polyethylene-plastic, sealed enclosure.

Rubber-sealed lids protect the test set from water and dust intrusion. Carrying handles are located on the top and sides for convenience.

For laboratory use, PULSAR can be ordered housed in a laboratory style configuration. The unit comes with panels and carrying handles mounted on the side of the chassis.

For protection in transit, the laboratory unit comes with a rugged, retracting-wheel carrying case. As the handle is extended, the sturdy wheels swing out of their recesses, and the case becomes a luggage cart and transit case in one.

The foam-lined case is designed to protect PULSAR from normal shock and vibration in transit.

PULSAR also can be ordered without enclosures for mounting in a standard, 19-in. (483-mm) rack.

Dimensions

Field Enclosure

With lids on
20 H x 22 W x 12.5 D in.
508 H x 558.8 W x 317.5 D mm

With lids off
20 H x 22 W x 10.25 D in.
508 H x 558.8 W x 260.4 D mm

Lab Enclosure

15.75 H x 18.75 W x 8.75 D in.
400 H x 476.3 W x 222.3 D mm

One technician can easily carry PULSAR.

Weight

Weight varies depending on the number of modules in the system. The weight shown below is for a complete three-phase test system, including the timer module, three current amplifier modules and three voltage amplifier modules.

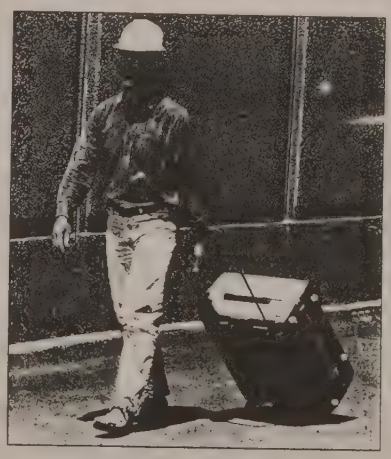
Field Enclosure

With lids on
73 lb (33.2 kg) approx

With lids off
64 lb (29.1 kg) approx

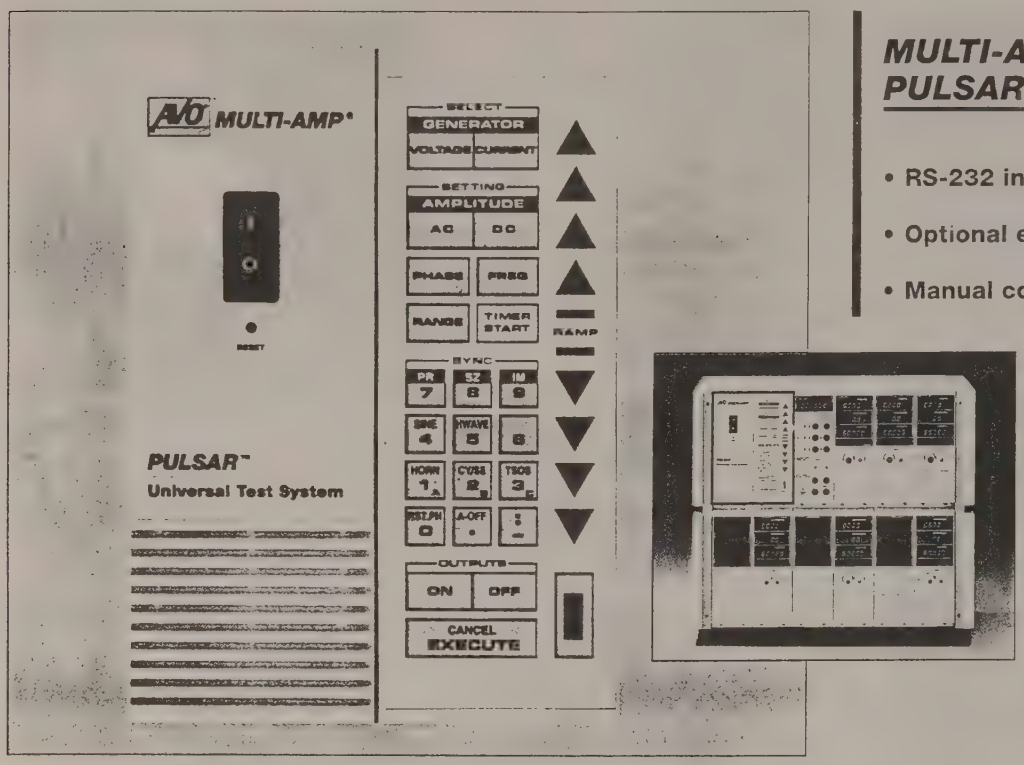
Lab Enclosure

57.5 lb (26.1 kg) approx



The laboratory-style unit comes with a retracting-wheel carrying case for easy transport.

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



MULTI-AMP® PULSAR®

- RS-232 interface port
- Optional expansion slot
- Manual control keypad

Input Power and Control Module

DESCRIPTION

This module is always located in the top-left corner of the unit. The module is divided into two sections: the power on-section (left half) and the control section (right half).

The power-on section performs the POWER ON and SYSTEM RESET operation. The control section via the keypad allows for the manual entry and control of the voltage, current, amplitudes, phase angle, frequency and range, as well as control of the TIMER START/STOP mechanism.

Also located in this module are the OPERATING SYSTEM WITH SYSTEM RESET button and the primary ac-to-dc power supply/power factor corrector.

FEATURES AND BENEFITS

• **Modular, plug-in design:** easy to replace or upgrade, thus minimizes downtime.

• **Keypad:** provides front-panel programmability for steady-state and dynamic testing.

• **Sealed-membrane switches:** prevent dust/dirt and moisture contamination —maintenance-free.

• **Auto-selectable input voltage:** Test system will operate on virtually any standard input voltage. No need to worry about connecting to the wrong input source.

• **Built-in RS-232 interface:** Unit can be used with any computer standard communication port. No need to purchase extra hardware to perform computerized testing.

• **Built-in expansion slot:** may be used for higher speed communication boards and future expansion applications.

SPECIFICATIONS

Input Power Requirements

Line Voltage: Auto-selectable from 95 to 265 Vac

Line Frequency: 47 to 63 Hz

Power Consumption: Depends on configuration and input voltage

Maximum: At 120 V OR 240 V, 1500 W, 50/60 Hz

Communication and Control Ports

RS-232 Interface: Standard baud rates available are 2400, 4800, and 9600 (switch-selectable).

Expansion Slot: For other control and communication boards. An optional IEEE-488 GPIB is available. (Refer to Ordering Information.)

Clock-In/Clock-Out and Sync-In/Sync-Out Ports: BNC connectors connect PULSAR with remote trigger pulse for external initiation (for GPS satellite synchronized testing applications).

Also allows two PULSAR units to be synchronized for "back-to-back" testing or six-phase applications.

Keypad: A 32-key, sealed-membrane keypad is provided for manual control of all test parameters.

These keys allow the operator to select voltage and/or current generators; select ac, dc or ac with dc offset amplitudes, phase angles and frequency; set ranges and start the timer.

Below the SETTING/AMPLITUDE keys are the alphanumeric keys. These can be used to enter numeric data or other functions.

The function keys are selected by the shift key located under the RAMP keys.

Control Functions Available

SYNC/PR: Denotes the PHASE REFERENCE key. Indicates that subsequent procedures will be executed at the master generator's positive-going zero-crossing phase reference.

SYNC/SZ: Denotes the SELF ZERO key. Indicates that subsequent procedures will be executed synchronous with each generator's own positive-going zero crossing.

SYNC/IM: Denotes the IMMEDIATE key. Indicates that subsequent procedures will be executed immediately (point-on-waveform).

HWAVE: Denotes the HALF-WAVE key. Indicates that a half-wave sine wave is to be generated by the selected generator(s). Used to simulate the half-wave rectified output of a diode for harmonic restraint tests.

SINE: Used to change selected output(s) back to a full sine wave.

HORN: Used to turn the tone generator on/off, which is associated with the monitor (CONTINUITY) mode of the Timer Module.

CY/SE: Used to toggle the timer display between seconds and cycles. In the cycles mode, an automatic division of seconds by the period is performed. The period is normally 50 or 60 Hz (set by internal jumper).

TSOS: Denotes timer stop on synchronization. Normally used when testing auto-synchronizing relays.

The timer is started by an action from the relay and stopped when the selected outputs come into synchronization.

RST PH: Used to restore the phase relationship between all generators. This is normally used when output frequency is changed, which can alter the phase relationship.

A-OFF: Allows the operator to have selected outputs turned off whenever the timer stop gate or monitor changes state.

Below the alphanumeric keypad are the ON, OFF and EXECUTE keys. These are used to turn outputs on and off, and to execute a string of commands immediately.

The EXECUTE key makes three-phase, manually operated, dynamic testing possible. The CANCEL key is used to cancel any previously selected function prior to pressing the EXECUTE key.

RAMP: The RAMP keys are located to the right side of the control section. The keys allow the operator to ramp up or down any selected output(s) including ac/dc voltage, current, phase angle and frequency.

Up arrows increment up, and down arrows increment down. The size of the increment varies depending on what is being ramped and the range.

The top-most and bottom-most arrows change the most significant digit. The arrows closest to the center increment the least-significant digit.

Temperature Range

Operating: 32 to 122° F (0 to 50° C)

Storage: –13 to +158° F (–25 to +70° C)

Humidity Range

0 to 90% RH, noncondensing

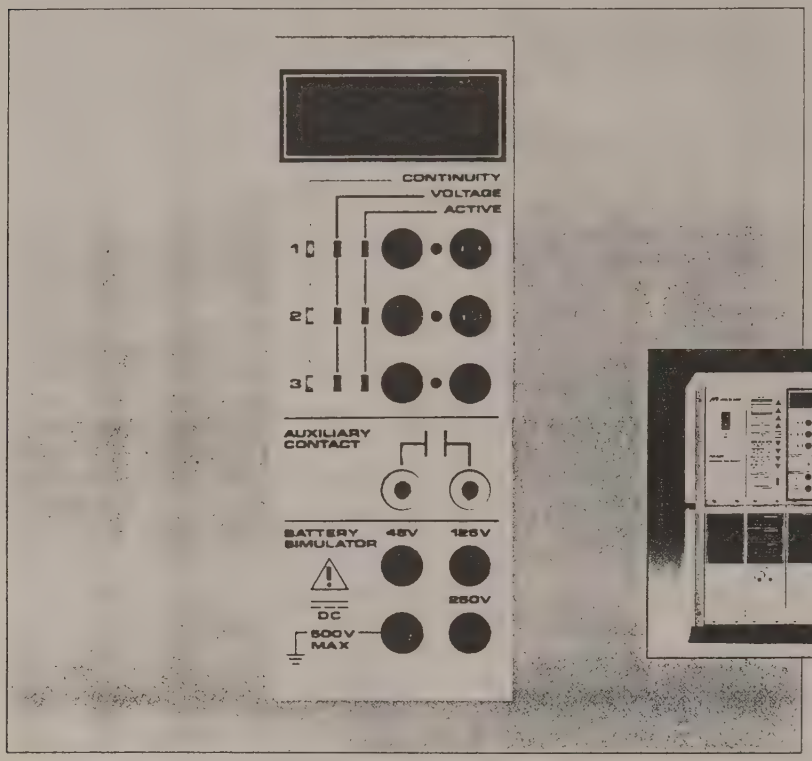
Dimensions

7.8 H x 5.3 W x 8.2 D in.
198.6 H x 134.6 W x 207.7 D mm

Net Weight

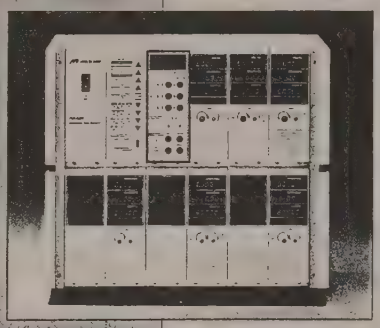
5.75 lb (2.6 kg)

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



MULTI-AMP® PULSAR®

- Times high-speed relays
- Multiple continuity monitors
- Eliminates need for dc voltage source



Timer, Monitor and Battery Simulator Module

DESCRIPTION

The Timer, Monitor and Battery Simulator Module is designed to slide into one slot of the PULSAR® unit.

The timer is specifically designed to measure high-speed operation of electromechanical, solid-state and microprocessor-based protective relays.

It incorporates three sets of banana-plug receptacles. These receptacles can be programmed as: start gates, stop gates, monitor; all stop gates; or all contact continuity monitors.

The programmable auxiliary contact can be opened or closed by software command. One application for this contact is to simulate breaker failure contact closure.

The battery simulator has four terminals providing three voltages: 48, 125 and 250 volts dc. The primary application is to provide logic voltage to solid-state and microprocessor-based relays.

FEATURES AND BENEFITS

- **Modular, plug-in design:** operator can easily reconfigure test systems to meet changing test requirements.
- **High resolution and accuracy:** provides capability to accurately time high-speed relays.
- **Multiple continuity monitors:** provides multiple contact monitoring without moving test leads.
- **Continuity light and audible tone generator:** monitor operation of the trip contact or trip SCR in the relay under test. The monitor circuit can be reprogrammed easily to be voltage-sensing and can monitor solid-state logic signals.

  This circuit senses a positive-going signal of 1 to 300 volts ac or dc. In addition, the lower threshold voltage is adjustable from 1 to 4 volts to eliminate false triggering due to noisy environments.
- **Programmable de-bounce:** used in eliminating false triggering and contact bounce errors.
- **Programmable contacts:** used to simulate the A/B contacts of a breaker for automatic testing of breaker failure relays.
- **Adjustable voltage thresholds:** Lower threshold may be used to start and stop the timer from TTL voltage signals.
- **Battery simulator:** eliminates need for additional dc voltage source.

SPECIFICATIONS

Display

The 6-digit, 0.3-in. (7.62-mm), high-intensity LED display ensures readability even in high-ambient light conditions.

Range and Resolution

Timer will display in either seconds or cycles, and will autodecade up with the following range and resolution:

Seconds
00.0001 to 99,999.9

Cycles
00.006 to 99,999.9 (at 60 Hz)
00.005 to 99,999.9 (at 50 Hz)

Accuracy

At 23° ±2° C, ±1 least-significant digit of resolution or ±0.002% of reading

At 0 to 50° C, ±0.005% of reading maximum

Initiation is by a dry contact or dc potential of 5 Vdc or by ac potential above 115 V*.

*Note: AC voltage accuracy is different at lower voltages. Worst case is ±8 ms (1 to 4 Vac rms adjustable threshold, just following wave shape peak).

Selectable Time Base

The time base used by the timer comes set from the factory at either 60 Hz or 50 Hz, depending on desired operating frequency.

By computer control, the time base can be any frequency from 0.1 Hz to 10 kHz. The typical programmable time base frequencies are 25, 50, 60 or 400 Hz.

Start/Stop/Monitor Gates

Three identical, independent, programmable start, stop or monitor gate circuits permit simple selection of the desired mode of operation.

To monitor operation of the contacts or trip SCR in the device under test, a continuity light is provided for each gate. The gate circuit is isolated for voltage-sensing and can monitor solid-state logic signals.

Upon sensing continuity or a voltage signal, the continuity lamp will glow, and a tone generator will sound if desired.

The following modes are provided for the Start/Stop/Monitor Gates:

- *Dry Contact Opens*: A change of state starts or stops the timer or continuity is indicated at the opening of normally closed contacts or when conduction through a semiconductor device such as a triac or transistor is interrupted.
- *Dry Contacts Close*: A change of state starts or stops the timer or continuity is indicated at the closing of normally open contacts or upon conduction through a semiconductor device such as a triac or transistor.
- *Application or Removal of AC or DC Voltage*: The timer starts, stops or continuity is indicated upon the application or removal of either an ac or dc voltage.

  The voltage threshold is adjustable from 1 to 4 V, ac or dc. A higher threshold voltage helps to eliminate false triggers due to a noisy source. Lower thresholds allow starting and stopping of timer from TTL voltage signals.

  The maximum allowable voltage applied is 300 Vac or 300 Vdc, limited by MOV transient protection.
- *Start or stop with any selected generator module*: The timer can be started or stopped when turning on or off any (or all) selected generators.
- *The timer can be started simultaneously* with a change in frequency, phase angle, amplitude or a waveform step.
- *The timer can be stopped upon phase synchronization* between two voltage channels (normally used to time autosynchronizing relays).

Start Latch

When LATCHED is selected, the start latch allows timing to be initiated by a start gate and to be stopped only by the selected stop gate.

When UNLATCHED, the start latch allows timing to be stopped when the start gate is reversed, such as when timing the closing and opening of a single contact, as in measuring the trip-free operating time of a circuit breaker.

Stop Latch

When LATCHED, the stop latch allows timing to be stopped at the first operation of any stop Gate, thus ignoring contact bounce.

When UNLATCHED, the stop latch allows timing to be stopped by any stop gate and then restarted if the stop gate reverses, provided a start gate is still energized, then stopped again when the gate reverses (total time including contact bounce).

Start/Stop Gate De-Bounce

The timer can be programmed to ignore temporary state changes that are less than a set duration. This is useful for eliminating false triggering and contact bounce errors.

De-Bounce Period: 0 to 999 ms

Resolution: 0.1 ms

Auxiliary Contact

A pair of banana-plug receptacles provides access to the programmable dry contact. The contact may be opened or closed by software command.

Maximum Switching Voltages: 110 Vac or 30 Vdc

Maximum Switching Currents: 0.3 A ac or 1.0 A dc

Closing Time: 1 ms typical

Opening Time: 0.5 ms typical

Battery Simulator

Output Voltages

Four banana-plug receptacles will provide the following voltages: 48, 125 and 250 Vdc. Only one output voltage may be used at a time.

Output Power: 60 W

Accuracy: ±20% max

Ripple: ±10% max

Temperature Range

Operating: 32 to 122° F (0 to 50° C)

Storage: –13 to +158° F (–25 to +70° C)

Humidity Range

0 to 90% RH, noncondensing

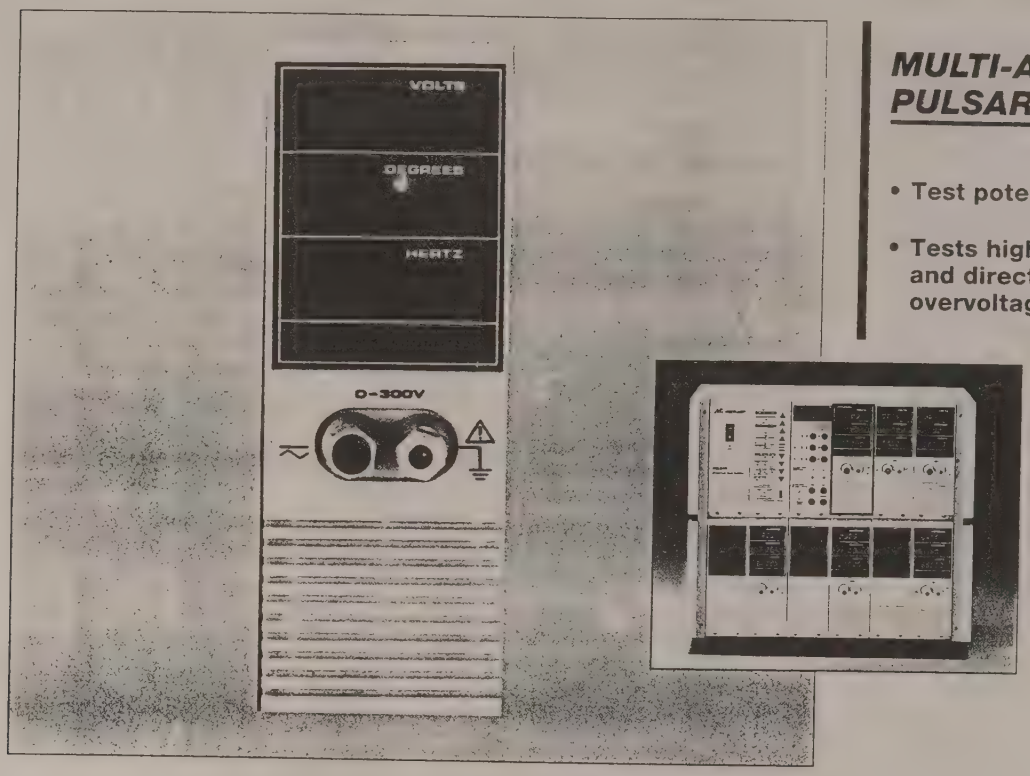
Dimensions

7.8 H x 2.7 W x 8.2 D in
198.6 H x 67.3 W x 207.7 D mm

Net Weight

2.93 lb (1.3 kg)

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



***MULTI-AMP*® *PULSAR*®**

- **Test potential to 600 V rms**
- **Tests high-instantaneous and direct-connected overvoltage relays**

Voltage Amplifier Module

DESCRIPTION

The Voltage Amplifier Module is designed to slide into one slot of the PULSAR® unit. One module can provide either ac or dc voltage output, 0 to 300 volts rms, or ac with dc offset, 425 volts peak.

Two modules will provide a three-phase, open-delta test source. Three modules will provide a complete three-phase, four-wire test source.

For higher test voltages (greater than 300 volts rms), two modules can be connected in series to double the test potential to 600 volts rms.

For special applications, the voltage amplifier module can provide a sine wave with varying percentage of harmonics and exponential decay or periodic arbitrary waveforms from Digital Fault Recorders or EMTP (Electro-Magnetic Transients Program) programs.

Other special application waveforms also are available.

FEATURES AND BENEFITS

- **Modular plug-in design:** provides flexibility to add to or reconfigure test system to meet changing test requirements.
- **High resolution and accuracy:** needed to test relays with higher sensitivity and accuracy requirements.
- **0 to 300 volts rms:** provides capability to test relays with high potential requirements such as directly connected or highly instantaneous overvoltage.
- **DC to 20 kHz bandwidth:** provides flexibility to test ac or dc relays, either steady-state, dynamic or transient.
- **User-defined waveforms:** The operator can use a computer to create specific waveforms for special test applications.

SPECIFICATIONS

Output Frequency and Displayed Resolution

The Voltage Amplifier Module provides a variable frequency output featuring automatic decading.

Frequency is continuously displayed for each channel with large, high-intensity LEDs with these ranges:

DC
00.001 to 99.999 Hz
100.01 to 999.99 Hz
1000.1 to 9999.9 Hz
10,000 to 20,000 Hz

Frequency Accuracy: ±10 ppm or ±0.0006 Hz at 60 Hz at 23° ±2° C

Output Power

Output (continuous)	RMS	Peak
50/60 Hz (sine wave)		
At 300 V		
(300-V range)	100 VA	200 VA
At 30 V		
(30-V range)	75 VA	150 VA
DC	100 W	——

Ranges (automatic range-switching) and Displayed Resolution

Volts RMS		Amperes RMS
0.0 to 300	at	0.33
0.00 to 30	at	2.5

Peak Output: 425 V

Resolution
Upper Range: 0.1 V
Low Range: 0.01 V

Duty Cycle: Continuous

Amplitude Accuracy
At 50 to 60 Hz:
10 to 100% of range
±0.5% at 23° ±2° C
±1.0% at 0 to 50° C

Total Harmonic Distortion

Less than 0.5% typical, 2% max. at 50/60 Hz

Phase Angle

Range: 0 to 359.9°

Resolution: 0.1°

Accuracy: less than ±0.2° typical, ±0.5° max at 50 or 60 Hz, full-scale voltage

Small-Signal Frequency Range

DC to 20 kHz into 10-kΩ load

Display

Each Voltage Amplifier Module contains a dedicated display to continuously show the output voltage (four digits), phase angle (four digits), frequency (five most-significant digits), output status (on or off) and dc offset when applicable.

Waveforms

DC; sine wave; sine wave with various percent of harmonics at various phases; periodic arbitrary waveforms from Digital Fault Recorders or EMTP/ATP programs; triangle and square waves with variable duty cycle, half wave, exponential decay. Arbitrary, nonperiodic waveforms from external analog inputs.

Waveform Storage

Each Voltage Amplifier Module has dedicated RAM storage for waveforms and/or transient waveform events.

Either 32 waveforms and/or events that are 4 k samples long, one waveform event that is 64 k samples long, or one waveform event up to 128 k samples long may be stored per channel and played back on command.

Temperature Range

Operating: 32 to 122° F (0 to 50° C)

Storage: –13 to +158° F (–25 to +70° C)

Humidity Range

0 to 90% RH, noncondensing

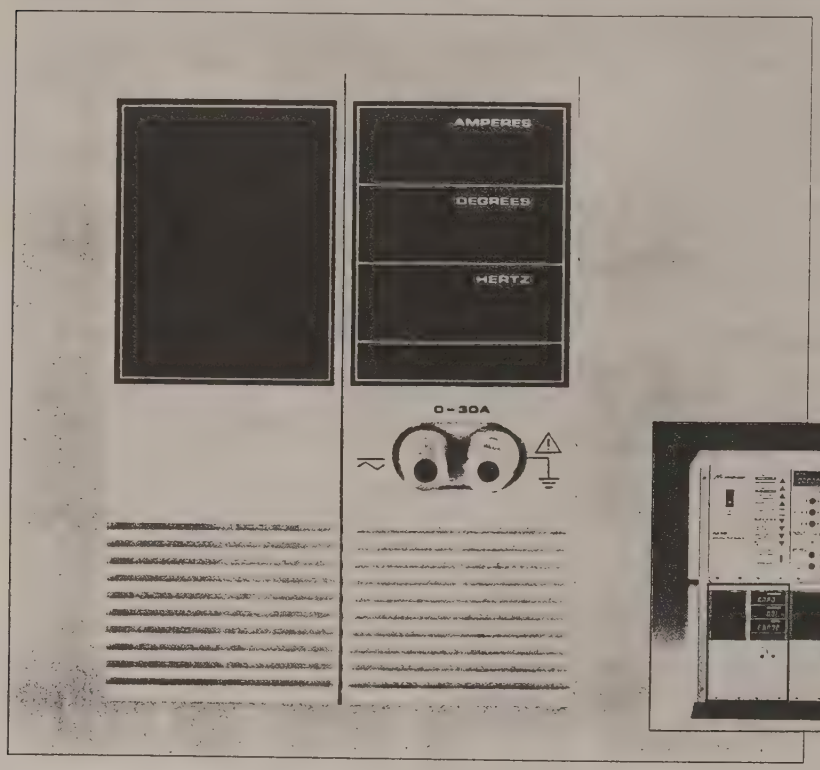
Dimensions

7.8 H x 2.7 W x 8.2 D in.
198.6 H x 67.3 W x 207.7 D mm

Net Weight

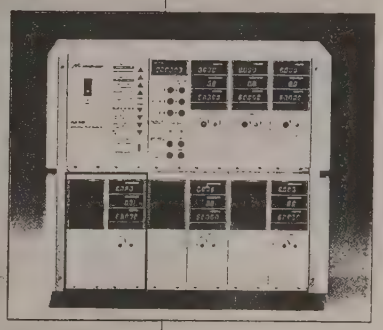
4.4 lb (2 kg)

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



MULTI-AMP PULSAR

- Parallel operation to 90 A
- DC to 20 kHz bandwidth
- High resolution, high accuracy
- 150 VA rms power



Current Amplifier Module

DESCRIPTION

The Current Amplifier Module is designed to slide into two slots of the PULSAR unit. One module can provide either 0 to 30 amperes ac or dc, or ac with dc offset, 42.5 amperes peak.

Two channels can be paralleled to provide 60 amperes ac at 300 VA, or three paralleled to provide 90 amperes ac at 450 VA.

For special applications, the Current Amplifier Module can provide a sine wave with varying percentages of harmonics and exponential decay or periodic arbitrary waveforms from Digital Fault Recorders or EMTP (Electro-Magnetic Transients Program) programs.

Other special application waveforms also are available.

FEATURES AND BENEFITS

- **Modular, plug-in design:** provides flexibility to add to or reconfigure test system to meet changing test requirements.
- **High resolution and accuracy:** provides capability to test relays with higher sensitivity or accuracy requirements.
- **Parallel operation up to 90 amperes:** Three current channels may be paralleled to test high instantaneous overcurrent elements.
- **DC to 20 kHz bandwidth:** provides flexibility to test ac or dc relays, either steady-state, dynamic or transient.
- **User-defined waveforms:** The operator can use a computer to create specific waveforms for special test applications.

SPECIFICATIONS

Output Frequency and Displayed Resolution

The Current Amplifier Module provides a variable frequency output featuring automatic decading. Frequency is continuously displayed for each channel with large, high-intensity LEDs with these ranges:

DC
00.001 to 99.999 Hz
100.01 to 999.99 Hz
1000.1 to 9999.9 Hz
10.000 to 20.000 Hz

Frequency Accuracy: ±10 ppm or ±0.0006 Hz at 60 Hz at 23° ± 2° C

Output Power

Output (continuous)

50/60 Hz (sine wave) RMS		Peak
At 30 A		
(30-A range)	150 VA	300 VA
At 15 A		
(15-A range)	150 VA	300 VA
At 3 A		
(3-A range)	150 VA	300 VA
DC	150 W	———

Ranges and Displayed Resolution

To meet a variety of test-circuit impedances, three output ranges are provided.

Only a single pair of output terminals is needed because impedance is automatically matched to the load by the microprocessor.

Amplitude is continuously displayed with large, high-intensity LEDs.

Amperes RMS		Volts RMS
0.00 to 30	at	5
0.00 to 15	at	10
0.000 to 3	at	50

Peak Output: 42.5 A

Resolution

Upper two ranges: 0.01 A
Low range: 0.001 A

Duty Cycle: Continuous

Amplitude Accuracy

At 50 or 60 Hz
10 to 100% of range
±0.5% at 23° ± 2° C
±1.0% at 0 to 50° C

Total Harmonic Distortion

Less than 0.5% typical, 2% max. at 50/60 Hz

Phase Angle

Range: 0 to 359.9°

Resolution: 0.1°

Accuracy: less than ±0.2° typical, ±0.5° max at 50 or 60 Hz, full-scale current

Small-Signal Frequency Range

DC to 20 kHz into 0.02-Ω load

Display

Each Current Amplifier Module contains a dedicated display to continuously show the output current (four digits), phase angle (four digits), frequency (five most significant digits), output status (on or off) and dc offset when applicable.

Waveforms

DC; sine wave; sine wave with various percent of harmonics at various phases; periodic arbitrary waveforms from Digital Fault Recorders or EMTP/ATP programs; triangle and square waves with variable duty cycles, half-wave and exponential decay. Arbitrary nonperiodic waveforms from external analog inputs.

Waveform Storage

Each Current Amplifier Module has dedicated RAM storage for waveforms and/or transient waveform events.

Either 32 waveforms and/or events that are each 4 k samples long, one waveform event that is 64 k samples long, or one waveform event 128 k samples long may be stored per channel and played back on command.

Temperature Range

Operating: 32 to 122° F (0 to 50° C)

Storage: –13 to +158° F (–25 to +70° C)

Humidity Range

0 to 90% RH, noncondensing

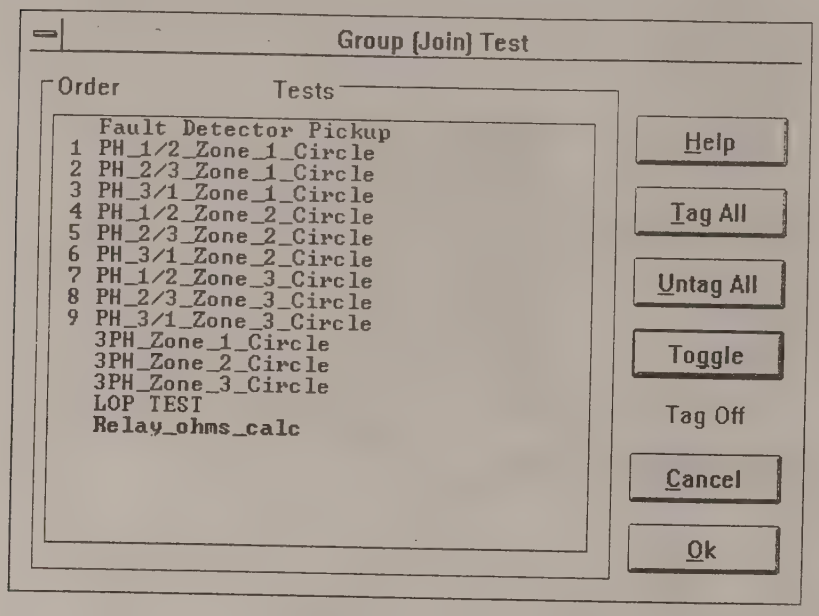
Dimensions

7.8 H x 5.3 W x 8.2 D in.
198.6 H x 134.6 W x 207.7 D mm

Net Weight

8.9 lb (4 kg)

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



MULTI-AMP® PULSEMASTER® VERSION 2.0

- **Designed for the Multi-Amp PULSAR® and EPOCH® test systems**
- **Records notes for future test reference**
- **Easily imports or exports test data**
- **Tags tests for progressive execution**

Software Package for the MULTI-AMP® PULSAR®

DESCRIPTION

The Multi-Amp® PulseMaster® Version 2.0 software package is a comprehensive and integrated program that works within Microsoft® Windows® to manage all aspects of protective relay testing.

Designed for the Multi-Amp PULSAR® and EPOCH® relay test systems, PulseMaster Version 2.0 provides all the features you have liked and depended on in the first PulseMaster release. With the enhanced Version 2.0, you can add notes to your test results for future reference. The program's easy-to-use data base menu allows you to easily import or export test data. In addition, you can tag tests for progressive execution.

From test program development to data logging and report generation, to data base storage and retrieval — PulseMaster has it all. It features powerful programming, scientific calculation and analytical capabilities for the protection engineer, and ease of use for the test technician.

APPLICATIONS

With PulseMaster's universal, general-purpose test routines, you can quickly and easily create your own customized, automatic relay test program for virtually any type of protective relay, regardless of the manufacturer. It allows you to test simple or complex, single- or three-phase, electromechanical, solid-state and microprocessor-based relays.

You do not need to change the way you test relays — you usually can substitute PulseMaster for your manual test procedures. Or, you can easily create new test procedures where previously none existed ... even for the most complex relays. After you have created your test program for a specific relay type, you can store it for recall and repetitive use.

With PulseMaster, you can perform steady-state, dynamic and transient testing. You can automatically change voltage, current, phase angle and frequency (including harmonics), ramp outputs and pulse outputs.

FEATURES AND BENEFITS

In addition to performing steady-state and dynamic tests, new relay test macros are now available which provide new testing capabilities for evaluating protective relays and relay schemes.

The unique combination of PULSAR's state-of-the-art Digital Signal Processor (DSP)-based hardware and PulseMaster software provides a powerful testing system capable of performing power system simulations in the lab or field. The test system can accurately reproduce a fault from a digital fault recording (DFR) or a fault simulation using the ElectroMagnetic Transients Program (EMTP)/Alternative Transients Program (ATP) in the IEEE COMTRADE ASCII file format.

End-to-end performance of the protective relay scheme can be evaluated when the test system is initiated by the Global Positioning System (GPS) satellite receivers.

• User-friendly and versatile: PulseMaster uses an advanced, Windows-based user interface with on-line help screens which make the software easy to use.

• Runs on Microsoft® Windows®: Reduces memory constraints associated with DOS-based testing software. The program provides graphical user interface in multi-tasking environments. You also can use test files created for Multi-Amp MasterTest™ with the PulseMaster program.

• Performs AS FOUND and AS LEFT tests: The program can compare test results with manufacturers' or user-defined specifications. In addition, enhanced graphics can plot test data on standard, grid, polar, semi-log, log-log, proportional or non-proportional graphs

• Performs dynamic and transient tests: The PULSE TIME feature allows the outputs to be set for a fault condition for PULSE seconds and then return to their steady-state condition. This feature allows dynamic testing on distance relay schemes without having to defeat the Zone 2 or Zone 3 timers. When used with a PULSAR, the DFR playback capability allows you to test a relay under "real-world" fault conditions. This is done by actual reproduction of recorded faults from digital fault recorders or simulations from EMTP/ATP files in the IEEE COMTRADE ASCII format.

• Exceptional printing capabilities: With the Microsoft Windows printer support, virtually any printer including laser printers can be used to print results or generate reports. You can print test reports for documentation and analysis, and store test results with your comments in the program's built-in data base. PulseMaster also prints and stores operating characteristics such as impedance diagrams and timing curves.

• Powerful dBASE IV-compatible data base: It retrieves (filters) test reports and graphs based on user-specified criteria. Built-in dBASE IV Version 1.5-compatible data base allows for record storage and retrieval. It also allows report generation in a customized format. New data base features include the capability to add notes to test results for future reference. In addition to providing the ultimate testing tools, its data base menu helps import or export test data with ease.

• Progressive testing capability: Tests within a given test file may be tagged for progressive execution.

• Your choice of computer interface: If you don't intend to use the IEEE-488 GPIB interface, you can use an RS-232 communication cable to send data to the PULSAR system. (Note: EPOCHs require the IEEE-488 interface.)

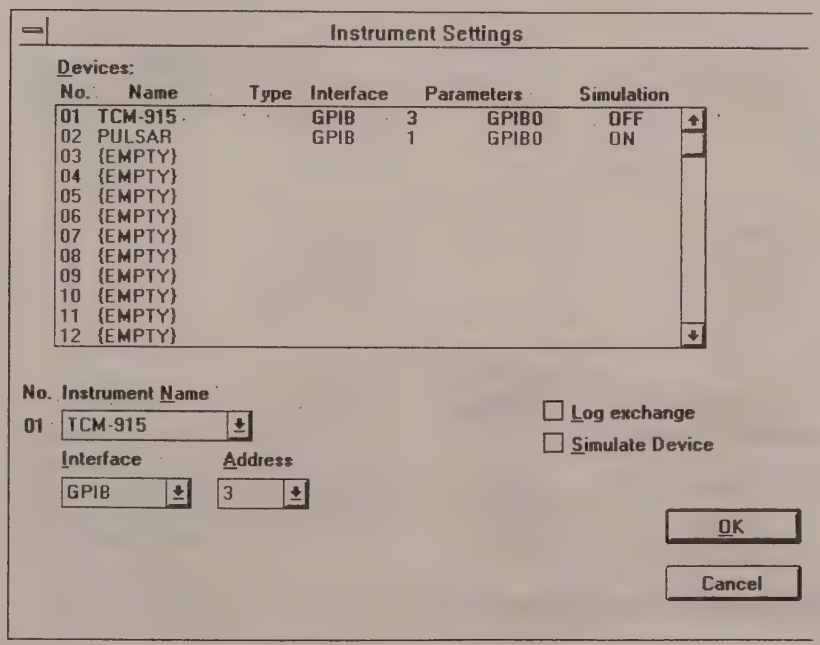
• Easily user-modified: The PulseMaster software program was designed to be user-modified. This was accomplished by developing a program which in itself can be programmed. All the testing and printout capabilities of this program come from macro files that the program interprets to perform the tests. These macro files give the user ultimate control of how a test is performed.

All the testing in the base program was created on a user's level and thus ensures that the user can modify or replace any aspect of the testing or printout process.

• Powerful programming environment: The syntax of the internal interpreter follows BASIC or GW-BASIC programming language whenever possible. In addition to this, power commands have been added with special functions for controlling test sets.

Each function of the test equipment is assigned a variable name. This allows the user to control the test equipment by simply setting variables in the interpreter and thus eliminates all the input/output (I/O) problems associated with controlling devices on the IEEE-488 interface bus.

• Windows Object Linking and Embedding (OLE): Through OLE, PulseMaster's macro interpreter allows execution of tests contained in the Multi-Amp PulseVector™ or PulseMonitor™ Software for the Multi-Amp Model TCM-915 Timer-Control-Monitor Unit.



Instrument Settings dialog box: Provides capability for user to define each instrument and its interface to each program. It is shared information for use with PULSAR, Model TCM-915 and other devices.

• Flexible skill-level operation: Program operation is designed for users with different skill levels. These levels are defined as:

Level 1

This level is designed for a user with knowledge of relay testing and minimal computer skills.

Level 2

This level is designed for users with a solid knowledge of relay testing and some computer or programming experience.

Level 3

This level is the most complex, but provides the user with considerable testing power. This user should have a solid understanding of computers, relays and the BASIC programming language.

• Comprehensive service support: During the first 90 days after PulseMaster is shipped to you, you have full access to support personnel who will answer your questions.

CUSTOMER SUPPORT

If you need ongoing help after the 90-day period, you can subscribe to the PulseMaster Extended Software Support Program. This program is an annual subscription offering PulseMaster users direct, toll-free access to support personnel and technical assistance.

In addition to professional programming support, new test modules and macros are available to subscribers of the Software Support Program. New test modules and macros are developed monthly and made available to subscribers through the **AVO** International Electronic Bulletin Board System (BBS).

The Extended Software Support Program also provides a free copy of any new releases or updates of the program for one year.

For more information, contact the Technical Marketing and Support Department at (214) 333-3201.

MINIMUM PC SYSTEM REQUIREMENTS

• IBM PC (80386 recommended), Portable PC or 100-percent compatible

• PC/MS-DOS Version 5.0 or later

• Microsoft Windows Version 3.1 or later

• One 3.5-in. floppy diskette drive, high-density

• Any video monitor supported by Microsoft Windows drivers

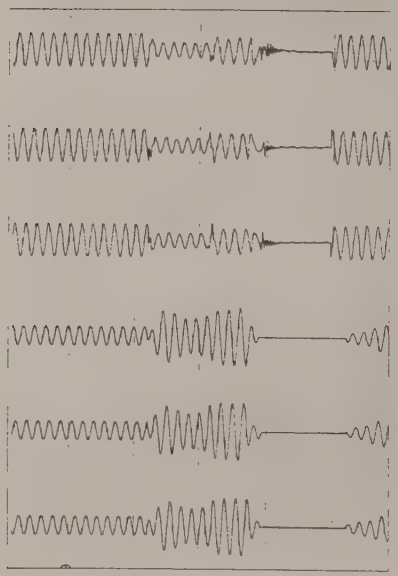
• 40-MB hard disk or larger is recommended

• 4-MB RAM minimum; 8 MB recommended

• National Instruments IEEE-488 GPIB Interface Device with associated driver software (for IBM PC, Portable PC or 100-percent compatible) is required for EPOCH units and is optional with PULSAR.

• Any printer supported by Microsoft Windows if hard-copy printouts are desired

• If serial communication is desired, an RS-232 COM port is needed.



PULSAR/PulseMaster Transient Settings: Playback from EMTP/ATP; three-phase faults with reclose

FOR ORDERING INFORMATION, REFER TO PAGE 18.

ORDERING INFORMATION

PULSAR Universal Relay Test System

Order PULSAR configured to your specific application requirements. To determine the catalog number, fill in the blanks below with corresponding number or letter from the detailed information boxes.

ORDERING EXAMPLE:

To order PULSAR Base Unit (1) with: one High-Current Interface Module (1); in the field enclosure (E); two Current Amplifier Modules (2); the Timer, Monitor and Battery Simulator Module (T); three Voltage Amplifier Modules (3); an optional GPIB Interface (G); for North America (1/60), request the following catalog number: **11E2T3G-1/60**.

1 1 E 2 T 3 G – 1 / 60

Fill in these blanks with the corresponding number or letter.

1 ___ ___ ___ ___ ___ ___ – ___ / ___

PULSAR Base Unit
1 = Includes chassis, back plane, and Input Power and Control Module.

High-Current Interface Module
Enter **0**, **1**, **2** or **3** for the number of High-Current Interface Modules required.

Enclosure Options
Enter **E** = Enclosure. Unit comes installed in a rugged field enclosure.
Enter **L** = Unit comes with enclosure for laboratory/benchtop use, includes rugged, reuseable transit case.
Enter **R** = Rack-mountable. Unit is ready for mounting in a 19-inch rack.

Current Amplifier Modules
Enter **0**, **1**, **2** or **3** for the number of Current Amplifier Modules required.

Operating Frequency
Enter **50** = 50-Hz system
Enter **60** = 60-Hz system

Power Cord Option
Enter **1** = North America
Enter **2** = International
Enter **3** = Continental Europe

Expansion Slot Option
Enter **N** = None
Enter **G** = GPIB

Voltage Amplifier Modules
Enter **0**, **1**, **2** or **3** for the number of Voltage Amplifier Modules required.

Timer, Monitor and Battery Simulator Module
Enter **T** = Unit comes with Timer, Monitor and Battery Simulator.
NOTE: This module is required for timing tests and to monitor contacts
Enter **N** = No Timer, Monitor and Battery Simulator is desired.

Item (Qty)	Cat. No.
Included Accessories	
Test leads	
The appropriate number of test leads is included depending on the PULSAR system ordered. Refer to next page for ordering information on test leads for additional modules.	
Accessory kit includes:	
Carrying case for leads (1)	14573
Instruction manual (1)	14849

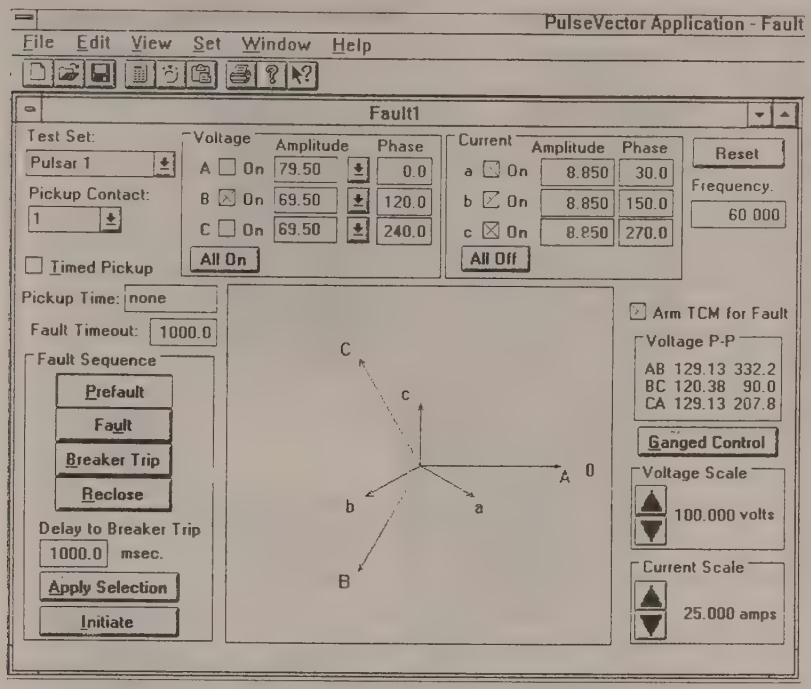
Item (Qty)	Cat. No.
Power Cord Options	
North America line cord	14460
International line cord	14525
Continental Europe line cord	15021
Laboratory Unit	
Reusable transit case	15867

REFER TO PAGE 18 FOR ADDITIONAL ORDERING INFORMATION.

ORDERING INFORMATION

Item (Qty)	Cat. No.
Additional PULSAR Modules	
Voltage Amplifier Module	15073
Included Accessories	
Test leads (1 pr)	1282
Installation instructions	13748
Carrying case	15105
Current Amplifier Module	16824
Included Accessories	
Test leads (1 pr)	15922
Installation instructions	13760
Carrying case	14574
Timer, Monitor and Battery Simulator Module	15075
Included Accessories	
Test leads (5 pr)	1282
Installation instructions	14774
Carrying case	15105
High-Current Interface Module	15820
Included Accessories	
EPOCH-20 Interface cable (1)	15821
EPOCH-II Interface adapter (1)	15833
Blank module (1)	14327
Carrying case	14574

Item (Qty)	Cat. No.
PulseMaster Software Program	
PulseMaster Software Program	10095
Included Accessory	
Instruction manual (1)	10095IB
(Additional manuals available at quantity discounts)	
Extended Software Support Program	
1 to 2 users	10098
1 to 5 additional users	10097
6 or more additional users	10096
Expansion Slot Option	
IEEE-488 General Purpose Interface Board	15025



MULTI-AMP® PULSEVECTOR™

- **Simple "point-and-click" operation**
- **Does not require computer programming skills**
- **Performs steady-state and dynamic tests**

Relay Test Software

DESCRIPTION

The Multi-Amp® PulseVector™ Relay Test Software enables the relay test technician to easily perform steady-state and dynamic tests on virtually all protective relays. PulseVector provides simple "point-and-click" operation — technicians do not need computer programming skills to develop tests for automatic relay testing.

PulseVector®, a Microsoft® Windows®-based program, graphically displays voltage, current, frequency and phase angle relationships applied to the device under test by the Multi-Amp PULSAR® Universal Protective Relay Test System. Test routines can be stored later for testing similar relays.

APPLICATIONS

The traditional steady-state, or acceptance, tests are easily performed with PulseVector by simply applying the test quantities to the device under test and varying the current, voltage, frequency or phase angle.

When varying test quantities, a single phase, two phases or all three phases of voltage amplitude, current amplitude or any phase angle relationship may be changed simultaneously using the gang control feature. The test setup for a given configuration may be saved for repeated use.

Dynamic tests can easily be performed using PulseVector. The dynamic test setup includes setting prefault, fault, breaker trip time, reclose time and post-fault values.

Not only can the voltage, current and phase relationships be established, the prefault, breaker trip, reclose and post-fault durations can be precisely defined with 0.1-millisecond resolution.

FEATURES AND BENEFITS

• Steady-state, or acceptance tests are easily performed with PulseVector by simply applying the test quantities to the device under test and varying the current, voltage, frequency or phase angle using a pointing device (mouse). Test parameters are set with minimum effort.

• Dynamic tests can easily be performed using PulseVector. The dynamic test setup includes the setting prefault, fault, breaker trip time, reclose time and post-fault values.

Not only can the voltage, current and phase relationships be established, the prefault, breaker trip, reclose and post-fault durations can be precisely defined with 0.1-millisecond resolution.

• Tests defined with PulseVector may be executed from PulseMaster® Version 2.0 using the Object Linking and Embedding (OLE) features of Windows.

• The Timer Configuration Dialog Box enables the operator to easily set the PULSAR timer to the desired configuration. This includes post number, continuity, voltage applied or removed, latched or unlatched. The posts can be set as TIMER START, TIMER STOP or MONITOR. Also, the debounce time can be specified for each post (to eliminate false trigger or contact bounce problems).

• PulseVector can perform RESET and TRIGGER commands to PulseMonitor™ software, which controls the Model TCM-915 Timer-Control-Monitor Unit.

• Test configurations can be saved for retrieval and execution at a later date.

• The computer interface may be either RS-232 or IEEE-488.2 GPIB. The PULSAR unit must be equipped with the GPIB interface when this is the interface choice.

• During the first 90 days after PulseVector has been shipped to you, you have full access to customer support personnel who will answer your questions.

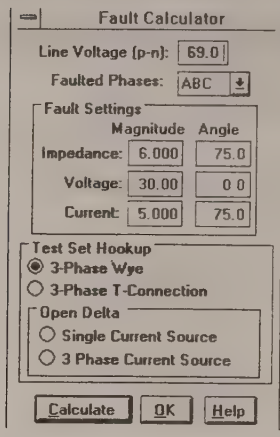


Fig. 1

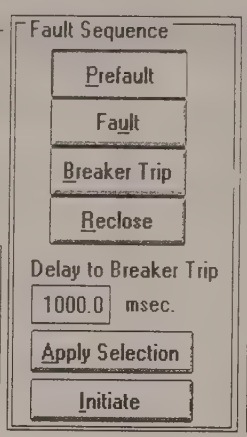


Fig. 2

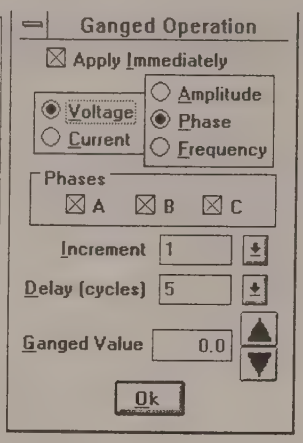


Fig. 3

PULSEVECTOR DIALOG BOXES

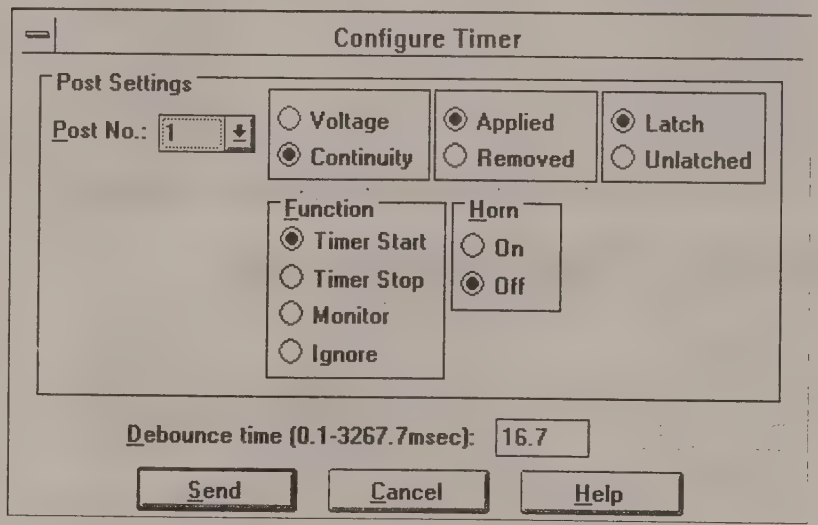
Fig. 1 Fault Calculator Dialog Box: Allows the user to easily calculate the fault quantities from a given set of fault parameters.

Fig. 2 Fault Sequence Configuration Dialog Box: Provides operator capability to set duration of prefault, fault, breaker trips and reclose times with resolution to 0.1 millisecond.

Fig. 3 Ganged Operation Dialog Box: These buttons are used to gang the selected parameters. The user selects a button and gangs the selected parameters using the mouse button or space bar.

• Using the PulseVector Fault Calculator, the operator simply enters the desired test voltage (or current), the fault impedance and fault angle, and the test current (or voltage) is calculated for the selected fault. Fault values may be calculated for phase-to-ground, phase-to-phase or three-phase faults for three-phase wye three-phase T or open-delta voltag onnections. Once the fault values ha been established, they may be applied directly to the fault sequence.

• To control individual voltage and current vectors, the selected quantity can be increased and decreased until the operating point has been established. Using a standard mouse control, click and drag the selected voltage vector with the left button to the desired amplitude and angle. Using the right mouse button, click and drag the selected current vector to the desired test values.



Timer Control Dialog Box: Used to help easily configure the PULSAR® timer terminals.

MINIMUM PC SYSTEM REQUIREMENTS

- IBM PC (80386) or 100% compatible
- PC/MS DOS Version 5.0 or later
- Microsoft Windows Version 3.1 or later
- One 3.5-in. floppy diskette drive. Drive may be double or high density.
- 4-MB RAM minimum; 8 MB recommended.
- If serial communication is desired, an RS-232 communications port is required.
- If GPIB communications is desired, a National Instruments IEEE-488.2 interface device with associated software is required.

CUSTOMER SUPPORT

If you need ongoing help after the 90-day period, you can subscribe to the **AVO** International Extended Software Support Program. This program is an annual subscription offering users of **AVO** International software direct, toll-free access to support personnel and technical assistance.

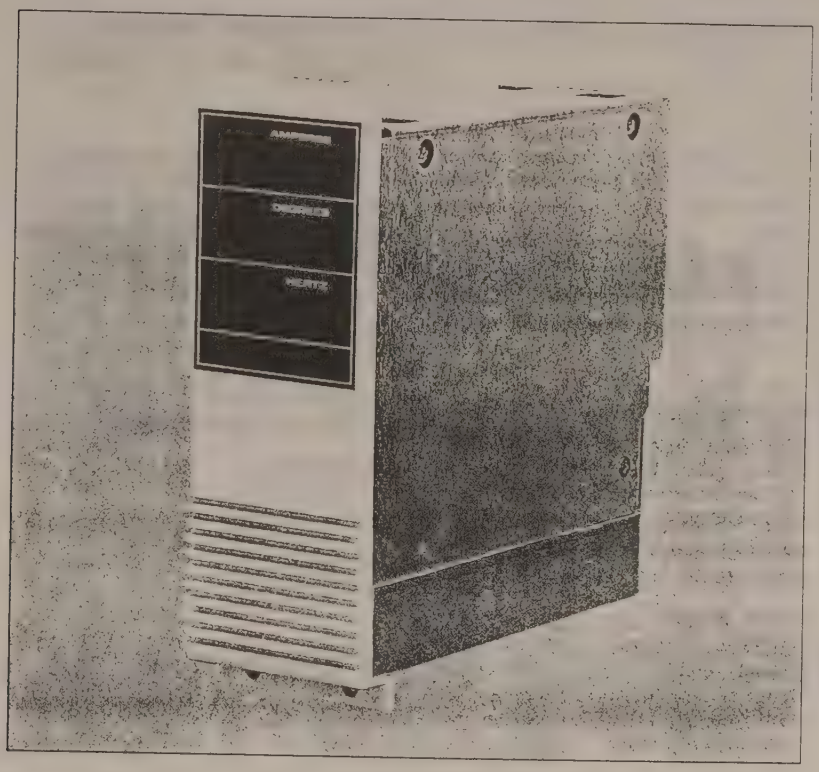
The Extended Software Support Program also provides access to an Electronic Bulletin Board System (BBS). This program also provides a free copy of any new releases or updates of the program during the subscription period.

For more information, contact the Technical Marketing and Support Department at (800) 723-AVO-1.

ORDERING INFORMATION

Item (Qty)	Cat. No.
PulseVector	10094
Instruction manual(1)	10094IB
(Additional manuals available at quantity discounts)	

Extended Software Support Program	
1 to 2 users	10098
1 to 5 additional users	10097
6 or more additional	10096



MULTI-AMP® Interface Module

- **Connects MULTI-AMP® PULSAR® to EPOCH-20® or EPOCH-II®**
- **Provides high-current, high-power testing capability**
- **High resolution, high accuracy**
- **Slides easily into PULSAR module slot**

PULSAR® High-Current Interface Module

DESCRIPTION

The Multi-Amp® PULSAR® High-Current Interface Module is a control interface between the PULSAR Universal Test System and Multi-Amp EPOCH-20® or EPOCH-II® High-Current Output Units.

It adds high-current, high volt-ampere output to PULSAR's relay testing capability and "one-box" convenience for single-phase, three-phase or six-phase testing.

The interface module is lightweight and is designed to slide easily into one slot of the PULSAR system.

APPLICATIONS

Typically, the interconnected PULSAR system and EPOCH high-current units would be used for testing instantaneous overcurrent and high-impedance ground overcurrent relays.

Other applications would include high-current, high volt-ampere uses such as testing short-reach distance relays or overcurrent relays with high multiples of tap.

For special testing applications, two or more EPOCH-20s or EPOCH-IIs can be operated in parallel with PULSAR to increase test current or volt-amperes.

For example, panel testing can be performed, which requires high volt-amperes to overcome high burdens due to several relays being connected in series.

The EPOCH-20 can provide an output up to 170 amperes at 600 volt-amperes rms. The EPOCH-II can provide 170 amperes at 1000 volt-amperes rms.

FEATURES AND BENEFITS

- Modular, plug-in design provides flexibility to add to or reconfigure test system to meet changing test requirements.
- High resolution, high accuracy provides capability to test relays with higher sensitivity or accuracy requirements.
- Only a minimal investment is required to interface PULSAR and the high-current EPOCH units.
- Up to nine interface modules can be installed in a PULSAR to control up to nine EPOCH-20 or EPOCH-II units. This feature allows for special applications, such as testing multi-terminal current differential relays.

SPECIFICATIONS

Output Ranges and Displayed Resolution

The EPOCH-20 and EPOCH-II have six output taps providing currents up to 170 amperes rms. The displayed resolution depends on which output tap is used and the desired output current.

EPOCH-20 Output

High Ranges: 600 VA rms
- 2 to 10.00 A at 60 V max
- 3 to 15.00 A at 40 V max
- 8 to 40.00 A at 15 V max
- 10 to 50.00 A at 12 V max
- 20 to 100.0 A at 6 V max
- 34 to 170.0 A at 3.5 V max

Low Ranges: 300 VA rms
- 2 to 10.00 A at 30 V max
- 3 to 15.00 A at 20 V max
- 8 to 40.00 A at 7.5 V max
- 10 to 50.00 A at 6 V max
- 20 to 100.0 A at 3 V max
- 34 to 170.0 A at 1.75 V max

Resolution
- Four Ranges: 0.01 A
- Two Ranges: 0.1 A

EPOCH-II Output

High Range
- 2.00 to 10.00 A at 100 V max
- 3.00 to 15.00 A at 66.6 V max
- 8.00 to 40.00 A at 25 V max
- 10.00 to 50.00 A at 20 V max
- 20.00 to 100.0 A at 10 V max
- 34.00 to 170.0 A at 5.9 V max

Output Power: 1000 VA

Low Range
- 2.00 to 10.00 A at 50 V max
- 3.00 to 15.00 A at 33.3 V max
- 8.00 to 40.00 A at 12.5 V max
- 10.00 to 50.00 A at 10 V max
- 20.00 to 100.0 A at 5 V max
- 34.00 to 170.0 A at 2.95 V max

Output Power: 500 VA

Resolution
- Four ranges: 0.01 A
- Two ranges: 0.1 A

Output Frequency and Displayed Resolution

The interface module provides a variable frequency signal to the EPOCH-20/EPOCH-II High-Current Output Unit. Output frequency is continuously displayed for each channel with large, high-intensity LEDs with the following ranges:

5.000 to 99.999 Hz
100.01 to 999.99 Hz

Frequency Accuracy: ±10 ppm at 23° ±2° C

Amplitude Accuracy

At 23° ±2° C, typical amplitude accuracy at 50 or 60 Hz will be ±0.5% of setting throughout range of load, 10 to 100% of range and range of input voltage.

Amplitude accuracy of ±1.0% of setting maximum 0 to 50° C.

Phase Angle

Range: 0 to 359.9°
Resolution: 0.1°
Accuracy: less than ± 0.2° typical, ±0.5° maximum at 50 or 60 Hz, full-scale current

Total Harmonic Distortion

Less than 1% typical, 2% maximum, at 50/60 Hz

Display

The current channel contains a dedicated display to continuously show the output current (four digits); phase angle (four digits); frequency (five most significant digits) and output status (on or off).

Temperature Range

Operating: 32 to 122° F (0 to 50° C)
Storage: -13 to 158° F (-25 to 70° C)

Humidity Range

0 to 90% RH, noncondensing

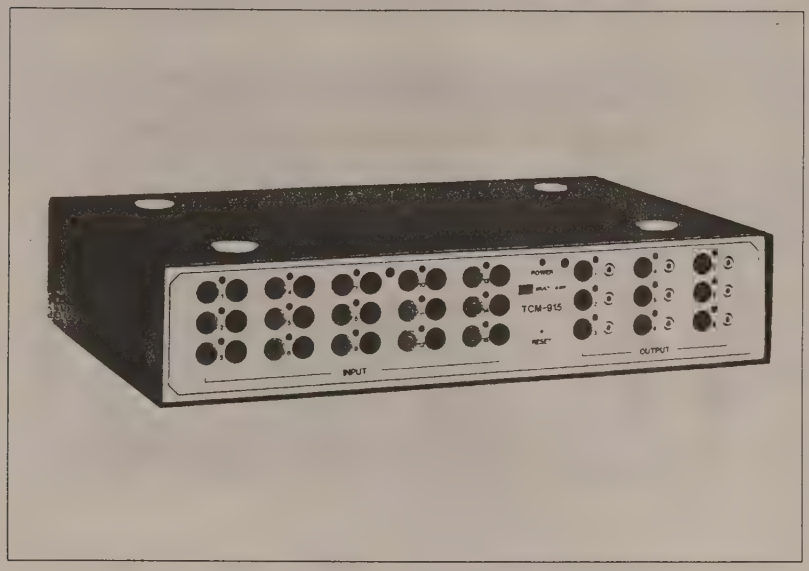
Dimensions

7.8 H x 2.7 W x 8.2 D in.
198.6 H x 67.3 W x 207.7 D mm

Net Weight

1.96 lbs (.89 kg)

FOR ORDERING INFORMATION, REFER TO PAGES 17 and 18.



MULTI-AMP® Model TCM-915

- **Fifteen inputs for monitoring with 1-ms accuracy**
- **Nine outputs for controlling device under test with 1-ms accuracy**
- **Two or more units can be used simultaneously**

Timer-Control-Monitor Unit

DESCRIPTION

The Multi-Amp® Model TCM-915 Timer-Control-Monitor Unit is designed to enable the user to control nine outputs and monitor fifteen inputs individually in a real-time environment.

A user-friendly software package enables the operator to communicate with Model TCM-915 via an IEEE-488 General Purpose Interface Bus. Connections to the unit may be made using standard test leads with banana plugs or a multiconductor connector on the rear of the unit.

When testing protective relays with multiple output and input signals, this instrument will enable the user to verify the proper operation of all outputs from the relay during a single test.

Designed to operate in conjunction with the Multi-Amp PULSAR® and EPOCH® test equipment, Model TCM-915 timing functions can be synchronized with the output of the PULSAR or EPOCH units.

The unit may be used as an independent instrument to monitor and measure the operating times of up to fifteen device inputs change-of-state. In addition, a stimulus can be provided by the nine output contacts of the unit to enable the user to perform a complete operational test on many control devices.

For special applications such as controlling power relays, TTL outputs are available on the rear of the unit.

APPLICATIONS

Model TCM-915 allows full automation of tests by recording the operating times of multiple outputs during a single test and providing input controls to the device under test.

A typical application of Model TCM-915 is to test a modern impedance relay designed for transmission line protection.

Inputs would be connected to the output of each zone timer, carrier start and reclose initiate. The outputs from Model TCM-915 would be connected to the relay inputs for 52a or 52b switches, reclose block, carrier received, etc.

Using the software interface, the output contacts would be programmed to change state at a predetermined delay, or change state based on the input signal.

For example, a 52a switch delayed by the tripping time of a simulated circuit breaker would be programmed to change state from the output trip signal of the relay under test.

A simulated fault would be applied to the relay by a PULSAR. Model TCM-915 would begin recording time from the incidence of the fault. The outputs to the relay would occur at the predetermined times after the fault.

At the completion of the test, a review of each input and output and the operating time would determine the complete operational characteristic of the relay for the given fault.

Complex states can be detected by specifying a particular sequence of input events that in turn can cause a change of state of the specified output contact.

The recorder allows the test technician to verify that a specific sequence of events occurred during a particular test.

An intuitive command set, together with the control software for the personal computer provided, enables the user to efficiently configure the most complex tests.

Once a test sequence has been programmed, it can be saved and later reloaded from a file. This allows Model TCM-915 to be set up quickly for the defined configuration, allowing the specified test to be completed in the minimum amount of time.

Changes-of-state are displayed in graph form to enable the operator to review the sequence of events quickly and easily.

FEATURES AND BENEFITS

- Fifteen voltage wet or dry inputs for monitoring events save time in testing relays with multiple contacts.
- Nine output contacts simulate relay or system inputs in the power system to completely test relays removed from the power system.
- Outputs simulate normally open/normally closed contacts for testing breaker failure schemes.

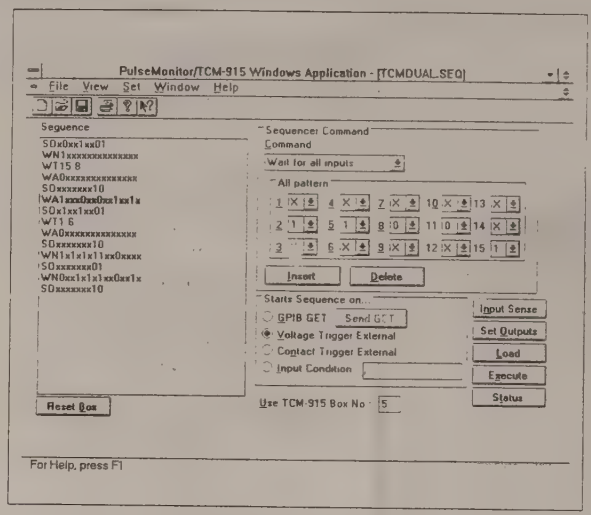


Figure 1: Input test sequence

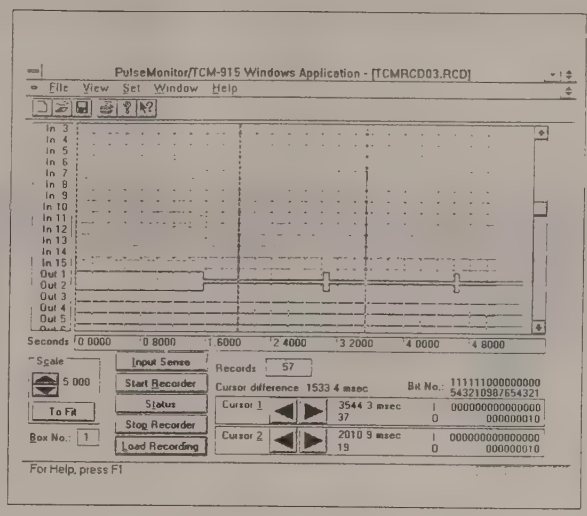


Figure 2: Timing results

• Each input/output has an LED indicator. The operator can check the status of each input and output easily.

• Inputs and outputs are accessible from the front of the unit via banana plugs or from the rear via a 48-pin connector. Connections using standard test leads or test connectors are simplified.

• Timing of events can be started by a Group Execute Trigger (GET) of the IEEE-488 bus or an input trigger on the rear panel. It can be used with Multi-Amp EPOCH or PULSAR relay test systems. It can also be triggered by GPS satellite for special test applications.

• Outputs can be configured to change state of an input state or a specified time delay after the change of state.

Provision for conditioned or dynamic testing of relays helps verify a sequence of events during a test.

• Two or more units can be used simultaneously. When the test calls for monitoring or controlling more circuits, additional units can be stacked. This provides expandability and flexibility.

• Multi-Amp PulseMonitor™ software records the inputs and outputs to ±1 ms resolution. This provides highly accurate monitoring and simulation of the system operation.

SPECIFICATIONS

Input

Input Power: Switched, 115/230 V ± 10%, 50/60 Hz

Input Circuits

15 Isolated programmable inputs
Normally open dry contacts
Normally closed dry contacts
Voltage applied
Voltage removed

Voltage Range: 5 to 250 Vdc or 40 to 300 Vac

Accuracy: ± 1 ms

Output Circuits

9 Isolated Programmable output contacts
Normally open contacts
Normally closed contacts

Contact Rating: 130 Vdc at 300 mA

Accuracy: ± 1 ms

Control

IEEE-488 General Purpose Interface Bus

Trigger Out: Provides a TTL output timing signal to synchronize the timing of other units.

Trigger In: TTL pulse input from another unit or a PULSAR unit synchronizes timing. Minimum pulse width is 50 ms.

Dry contact, active on closing

Enclosure

The unit is housed in a metallic enclosure for portability. In addition, hardware is included for mounting in a standard 19-in. (483-mm) rack.

Dimensions

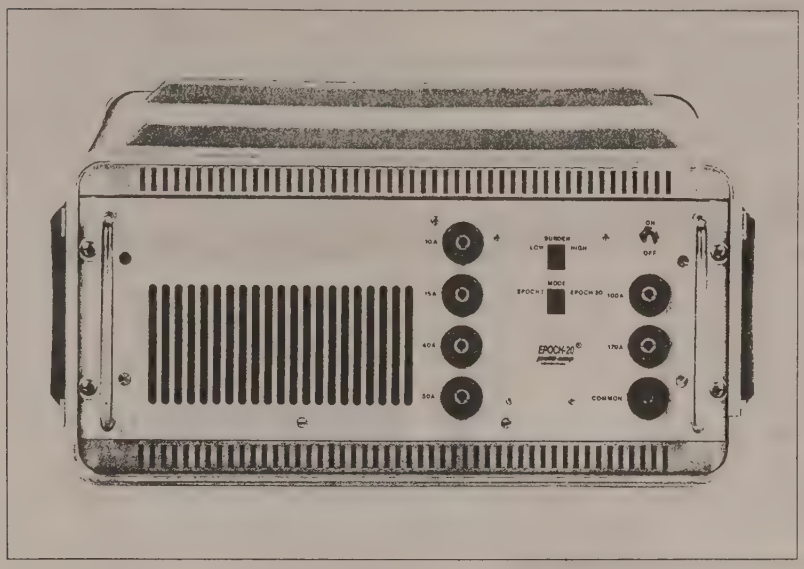
3.5 H x 17 W x 14 D in.
89 H x 432 W x 356 D mm

Net Weight

7 lb (6.8 kg)

ORDERING INFORMATION

Item	Cat. No.
Timer-Control-Monitor Unit	TCM-915
Included Accessories	
Line cord	1495
PulseMonitor software	10093
Instruction manual	16390
Optional Accessories	
48 pin female connector	16587



MULTI-AMP EPOCH-20

- **600 VA of high current**
- **Completely compatible with Multi-Amp PULSAR and EPOCH-10 protective relay test equipment**
- **Accurate test results**

High-Current Output Unit

DESCRIPTION

The Multi-Amp EPOCH-20 is a high-current output unit designed to be controlled by the Multi-Amp PULSAR in combination with the High-Current Interface Module to produce a rugged, portable, high-current, high-volt/ampere test set.

The EPOCH-20 also can be controlled by the Multi-Amp EPOCH-10 Relay Test Set.

PULSAR/EPOCH-20 or EPOCH-10/EPOCH-20 combination uses microprocessor-based, digitally synthesized sine wave generators and solid-state regulated power amplifiers to provide sinusoidal voltage and current outputs with precise control of the phase angle relationships.

These combinations will produce accurate test results even with a fluctuating power source or when testing nonlinear or highly saturable relays.

An optional IEEE-488 interface transforms the EPOCH-10/EPOCH-20 combination into a programmable automatic test system when used with an external controller or computer. Amplitude and/or phase angle can be set to desired values, step-changed, ramped or pulsed to new values.

APPLICATIONS

The PULSAR/EPOCH-20 or EPOCH-10/EPOCH-20 combination is designed to test both complex protective relays which require phase-shifting capability and simpler relays, including all overcurrent relays. The table above lists the different types of relays by device numbers along with the different combinations of PULSAR or EPOCH-10s and EPOCH-20s required to test them.

IEEE Device No.	Relay Types	Specify
50	Instantaneous Overcurrent up to 187 amperes at 600 VA	One EPOCH-20 and PULSAR with High-Current Interface Module or one EPOCH-10
51	Overcurrent up to 187 amperes at 600 VA	
67	Directional Overcurrent up to 187 amperes at 600 VA	
87	Differential	One EPOCH-20 and PULSAR with Interface Module or two EPOCH-10s
21	Distance (open-delta)	
21	Distance (wye)	One EPOCH-20 and PULSAR with Interface Module OR One EPOCH-20 and three EPOCH-10s OR Three EPOCH-20s and three EPOCH-10s OR Three EPOCH-20s and PULSAR with Interface Module

FEATURES AND BENEFITS

Each EPOCH-20 incorporates many standard features to reduce set-up time, simplify test procedures and increase accuracy.

- The EPOCH-20 is completely compatible with PULSAR via the High-Current Interface Module and the EPOCH-10.
- Output high-current source has a 3-minute duty cycle rating at 600 volt-amperes.
- Numerous protective circuits are incorporated, including thermal protection of the power amplifiers and overvoltage protection of the input circuit.
- Tough polyethylene plastic, sealed enclosure provides high shock and vibration resistance. Rubber sealed lids protect the test set from water and dust intrusion.
- To simulate the worst of field conditions, the EPOCH-20 has been tested and qualified in accordance with MIL-STD-810 for temperature, shock and vibration.

SPECIFICATIONS

Input

Input (specify one)

115 V ±10%, 50/60 Hz, 20 A
OR
230 V ±10%, 50/60 Hz, 20 A

Output

Output Current

To provide a variety of test circuit impedances, six output taps with two ranges are provided.

High Ranges: 600 VA rms
- 2.00 to 10.00 A at 60 V max
- 3.00 to 15.00 A at 40 V max
- 8.00 to 40.00 A at 15 V max
- 10.00 to 50.00 A at 12 V max
- 20.00 to 100.0 A at 6 V max
- 34.00 to 170.0 A at 3.5 V max

Low Ranges: 300 VA rms
- 2.00 to 10.00 A at 30 V max
- 3.00 to 15.00 A at 20 V max
- 8.00 to 40.00 A at 7.5 V max
- 10.00 to 50.00 A at 6 V max
- 20.00 to 100.0 A at 3 V max
- 34.00 to 170.0 A at 1.75 V max

Resolution
- Four Ranges: 0.01 A
- Two Ranges: 0.1 A

Overrange Capability

The EPOCH-20 has an overrange capability of ±10% for each tap with a maximum output current of 187 A on the 170-A tap.

Duty Cycle

Three minutes at full-rated VA output (i.e., 10 A at 60 V). Fifteen-minute recovery time

Accuracy

Typical: ±0.5% of setting
Maximum: ±1% of setting

Alarm will indicate when amplitude, phase angle, or waveform is in error.

Distortion

Less than 1% typical, 3% max

Output of EPOCH-10/EPOCH-20 Combination

Frequency

- Synchronized to input power source
- 60-Hz crystal-controlled
- 50-Hz crystal-controlled

Accuracy

- Synchronized, tracks input frequency
- ±0.006 Hz for 60-Hz crystal control ±0.01
- ±0.005 Hz for 50-Hz crystal control (0.01%)

Output of PULSAR and Interface Module Connected to EPOCH-20

The High-Current Interface Module provides a variable frequency signal to the EPOCH-20 High-Current Output Unit. Output frequency is continuously displayed for each channel with large, high-intensity LEDs with the following ranges:

5.000 to 99.999 Hz
100.01 to 999.99 Hz

Frequency Accuracy : ±10 ppm at 23° ± 2° C

Current Phase Angle Control

Angle is adjusted on the EPOCH-10 control unit by 4-digit, pushbutton control with large LED display of setting.

Range: 0.0 to 359.9°

Resolution: 0.1°

Accuracy: less than ±0.3° typical, ±1.0° max

Control Section

The control unit for the EPOCH-20 high-current section can be either PULSAR or an EPOCH-10. Thus the excellent operating and control features of PULSAR or the EPOCH-10 are used to control the EPOCH-20.

Note: When the EPOCH-20 is in use, the current output of the EPOCH-10 control unit is inoperative. All EPOCH-10s can control an EPOCH-20 high-current section. When the high-current section of the EPOCH-20 is not needed, the EPOCH-10 can be used independently or slaved together with other EPOCH units.

Harmonic Generator

Both the PULSAR and EPOCH-10 control units incorporate a special harmonic generator to test relays that include harmonic restraint elements such as transformer current differential relays.

This harmonic circuit provides the capability of converting the output current of the EPOCH-20 to either a second, third, or fifth harmonic of the frequency.

By simple use of a panel switch on the EPOCH-10, selection can be made for 60-, 120-, 180-, 300- or 50-, 100-, 150-Hz range.

Temperature

Operating

32 to 122° F (0 to 50° C)
Reduced duty cycle above 113° F (45° C)

Storage

77 to 158° F (25 to 70° C)

Dimensions

With Lids On

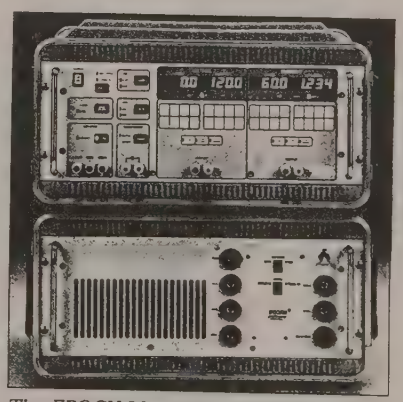
10.75 H X 21 W X 24.5 D in.
273 H X 533 W X 622 D mm

With Lids Off

10.75 H X 21 W X 18.5 D in.
273 H X 533 W X 470 D mm

Weight

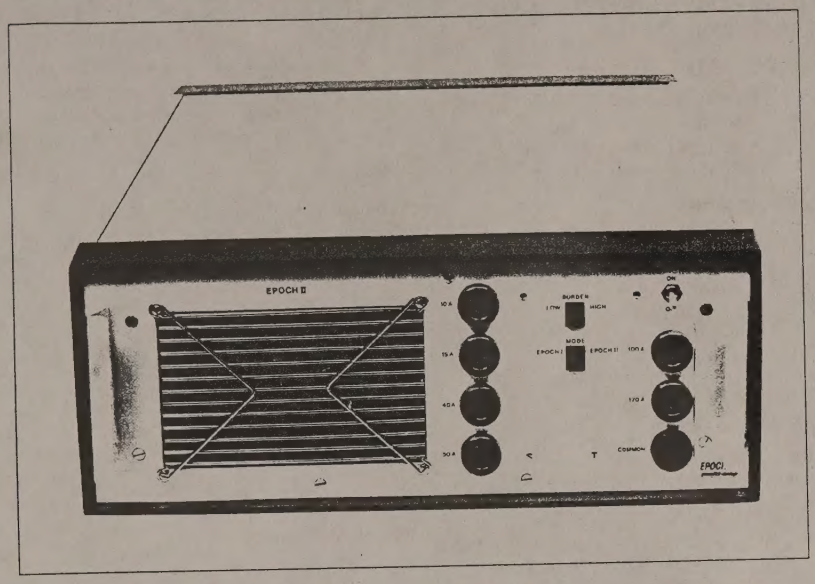
With Lids On: 83 lb (37.7 kg)
With Lids Off: 77 lb (34.9 kg)



The EPOCH-20 with the EPOCH-10 control unit

ORDERING INFORMATION

Item (Qty)	Cat. No.
PULSAR	
Refer to PULSAR catalog entry	
EPOCH-20	EPOCH20-STD
EPOCH-20 without enclosures, fits standard, 19-in.[483-mm] rack	EPOCH20-RK
Included Accessories	
Carrying case	11437
Fuses, 1.0 A, 250 V (5)	4139
Ground lead (1)	11258
High-current leads	
Black (1)	10708
Red (1)	11245
Power cord	11266
Interconnect cables	
Control (1)	10574
Signal (1)	11307
Instruction manual (1)	11275



MULTI-AMP® EPOCH-II®

- **1000 VA of high current**
- **Rugged, portable test set**
- **Highly accurate test results**

High-Current Output Unit

DESCRIPTION

The Multi-Amp® EPOCH-II® is a high-current output unit designed to be controlled by the Multi-Amp PULSAR® in combination with the High-Current Interface Module to produce a rugged, portable high-current, high-volt/ampere test set.

The EPOCH-II also is designed to be controlled by the Multi-Amp EPOCH-10® Relay Test Set.

PULSAR/EPOCH-II or EPOCH-10/EPOCH-II combination uses microprocessor-based, digitally synthesized sine wave generators and solid-state regulated power amplifiers to provide sinusoidal voltage and current outputs with precise control of the phase-angle relationships.

These combinations will produce accurate test results even with a fluctuating power source or when testing nonlinear or highly saturable relays.

An optional IEEE-488 GPIB interface transforms the EPOCH-10/EPOCH-II combination into a programmable automatic test system when used with an external controller or computer. Amplitude and/or phase angle can be set to desired values, step changed, ramped, or pulsed to new values.

Device No.	Relay Types	Specify
50	Instantaneous Overcurrent up to 187 A at 1000 VA	One EPOCH-II and PULSAR with High-Current Interface Module or one EPOCH-10
51	Overcurrent up to 187 A at 1000 VA	
67	Directional Overcurrent up to 187 A at 1000 VA	
67N	Ground Directional Overcurrent up to 187 A at 1000 VA	
87	All of the above plus. . . Differential	One EPOCH-II and PULSAR with Interface Module or two EPOCH-10s
21	Distance (open-delta)	
21	Distance (wye)	One EPOCH-II and PULSAR with Interface Module or three EPOCH-10s

APPLICATIONS

PULSAR/EPOCH-II or EPOCH-10/EPOCH-II combination is designed to test both complex protective relays which require phase-shifting capability and simpler relays, including all overcurrent relays.

The table above lists the different types of relays by device numbers, and the different combinations of a PULSAR or EPOCH-l0s and an EPOCH-II required to test them.

FEATURES AND BENEFITS

- Output current source has a 5-minute duty cycle rating of 1000 volt-amperes.
- Four output ranges at 0.01 ampere and two output ranges at 0.1 ampere are provided.
- Tough steel, sealed enclosure provides a high shock and vibration resistance.
- Completely compatible with PULSAR via the High-Current Interface Module and the EPOCH-10 units.

SPECIFICATIONS

Input

Input Voltage (specify one)
115 V ±10%, 50/60 Hz, 30 A
(at full rated output)
OR
230 V ±10%, 50/60 Hz, 20 A

Output

Output Current
To provide a variety of test circuit impedances, six output taps with two ranges are provided.

High Range
2.00 to 10.00 A at 100 V max
3.00 to 15.00 A at 66.6 V max
8.00 to 40.00 A at 25 V max
10.00 to 50.00 A at 20 V max
20.00 to 100.0 A at 10 V max
34.00 to 170.0 A at 5.9 V max

Output Power: 1000 VA

Low Range
2.00 to 10.00 A at 50 V max
3.00 to 1 5.00 A at 33.3 V max
8.00 to 40.00 A at 12.5 V max
10.00 to 50.00 A at 10 V max
20.00 to 100.0 A at 5 V max
34.00 to 170.0 A at 2.95 V max

Output Power: 500 VA

Accuracy
Typical: ±0.5% of setting
Maximum: ±1.0% of setting

Alarm will indicate when amplitude, phase angle, or waveform is in error.

Resolution
Four ranges: 0.01 A
Two ranges: 0.l A

Duty Cycle
Five minutes at full rated VA output. Fifteen minutes recovery time.

Overrange Capability
The EPOCH-II has an overrange capability of +10% for each tap with a maximum output current of 187 A on the 170 A tap.

Distortion
Less than 1% typical, 3% max.

Output of EPOCH-10/EPOCH-II Combination

Frequency

- Synchronized to input power source
- 60 Hz crystal-controlled
- 50 Hz crystal-controlled

Accuracy

- Synchronized, tracks input frequency
- ±0.006 Hz for 60-Hz crystal control (±001%)
- ±0.005 Hz for 50-Hz crystal control (±0.01%)

Output of PULSAR and Interface Module Connected to EPOCH-II

The High-Current Interface Module provides a variable frequency signal to the EPOCH-II High-Current Output Unit.

Output frequency is continuously displayed for each channel with large, high-intensity LEDs with the following ranges:

5.000 to 99.999 Hz
100.01 to 999.99 Hz

Frequency Accuracy: ±10 ppm at 23° C, ±2°C)

Current Phase Angle Control

Angle is adjusted on the EPOCH-10 control unit by 4-digit, pushbutton control with large LED display of setting.

Range: 0.0 to 359.9°

Resolution: 0.1°

Accuracy: less than ±0.3° typical, ±1.0° max

Control Section

The control unit for the EPOCH-II high-current section is PULSAR (with the High-Current Interface Module), an EPOCH-I or EPOCH-10.

Thus, the excellent operating and control features of PULSAR and the EPOCH-10 are used to control the EPOCH-II.

Note: When the EPOCH-II is in use, the current output of the EPOCH-10 control unit is inoperative. All EPOCH-10s can control an EPOCH-II high-current section. When the high-current section of the EPOCH-II is not needed, the EPOCH-10 can be used independently or slaved together with other EPOCH units.

Protection

The input line circuit is breaker-protected. The dc power supply is overcurrent-protected. In addition, overvoltage protection is provided on the input line circuit.

The power amplifiers are forced-air cooled and are protected by thermal-overload sensors.

Audio and visual alarms on the PULSAR and EPOCH-10 control units indicate whenever the current or potential outputs are overloaded.

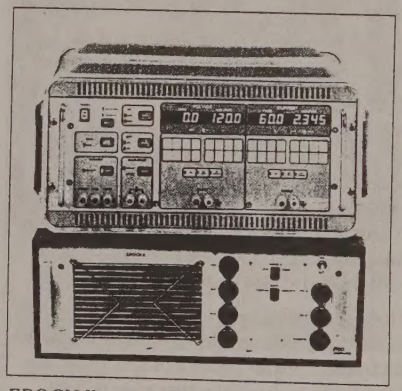
Temperature

Operating
32 to 122° F (0 to 50° C)
Reduced duty cycle above 113° F (45° C)

Storage
–13 to +158° F (–25° to +70° C)

Dimensions
7.6 H x 19.75 W x 21.6 D in.
(193 H x 502 W x 549 D mm)

Weight
115 lb (52.3 kg)



EPOCH-II with EPOCH-10 control unit

ORDERING INFORMATION

Item (Qty)	Cat. No.
PULSAR	Refer to pages 17-18
EPOCH-II	EPOCHII-STD
EPOCH-II without enclosures, fits standard, 19-in. [483-mm] rack	EPOCHII-RK

Included Accessories

Carrying case	11437
Fuses, 1.0 A, 250 V (5)	4139
Ground lead (1)	11258
High-current leads	
Black (1)	10708
Red (1)	11245
Power cord	11266
Interconnect cables	
Control (1)	10574
Signal (1)	11307
Instruction manual (1)	10709